Developing a Scoring Model for Optimal Selection of IT Programs to Reduce Wasted Investments

by Sarah Betadam

B.S. in BS, Computer Science & Applied Arts, May 2002, San Diego State University
M.S. in Computer Science & Engineering, December 2013, Santa Clara University

A Praxis submitted to

The Faculty of
The School of Engineering and Applied Science
of The George Washington University
in partial fulfillment of the requirements
for the degree of Doctor of Engineering

January 10, 2020

Praxis directed by

Amir Etemadi
Associate Professor of Engineering and Applied Science

Timothy Blackburn
Professorial Lecturer of Engineering Management and Systems Engineering

The School of Engineering and Applied Science of The George Washington University certifies that John Howard Doe has passed the Final Examination for the degree of Doctor of Engineering as of October 15, 2019. This is the final and approved form of the Praxis.

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Sarah Betadam

Praxis Research Committee:

Amir Etemadi, Associate Professor of Engineering and Applied Science, Praxis Co-Director

Timothy Blackburn, Professorial Lecturer of Engineering Management and Systems Engineering, Praxis Co-Director

Ebrahim Malalla, Visiting Associate Professor of Engineering and Applied Science, Committee Member

Dedication

I dedicate my praxis to my loving family who supported me throughout my academic career and during the last two years. I would not be able to achieve as far as I have gotten without them.

Acknowledgements

I want to acknowledge my parents, Edward Betadam and Agnes Adam, my husband David Nelson, and my brother Patrick Betadam for their loving support throughout my academic journey.

I also would like to acknowledge my advisor Prof. Amir Etemadi for his support and guidance throughout the praxis process.

Abstract of Praxis

Developing a Scoring Model for Optimal Selection of IT Programs to Reduce Wasted Investments

As early as 1984, researchers viewed IT program selection as a significant issue. Melone and Wharton (1984) were prescient when they expressed the necessity of having an "agreed upon set of factors used to evaluate IS [Information Systems] projects…[that] ...allows for an objective comparison of the strengths and weaknesses of alternative projects…" More recent academic research indicates a link between decision-making models and program success.

Furthermore, the popular view of the IT department as simply a cost center adds to business leaders paying close attention to the spending within IT and, by extension, a skeptical eye when looking at IT programs. It is unlikely that programs are considered in terms of providing any revenue, directly or indirectly, to the organization within the decision-making process. Some researchers suggest moving beyond that cost center mentality and instead regard the IT department as a revenue-producing area within the organization.

Towards the end of marrying both the decision-making model's ability to bring about program success and viewing IT programs from a return on investment perspective, this research proposes a multi-criteria model for selection of IT programs using an objective scoring method to commit investment to those programs offering the highest potential return on investment. This research identifies Business Capabilities, Resources, Program Dependencies and Business Values as significant criteria in selecting for program success and highest potential return on investment.

In order to validate the proposed decision-making model and the criteria, the model is implemented for use in the IT Program Management Office of a mid-size, Software as a Service corporation. Statistical analysis is then completed on the proposed model's accuracy and significance of the criteria against the existing legacy decision-making model and its criteria with both historical, pre-implementation program data and experimental, post-implementation program data.

The research identifies several proposed criteria as being statistically significant towards predicting program success in terms of return on investment as well as identifying two that are particularly significant. As a novel approach to IT program decision-making modeling, this research is able to confirm its feasibility and opens up avenues of future academic research towards other uses and forms of the approach.

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g	Final model (Random Forest)
f_i	Simple base model (Random Forest)
Y	Binary response variable -success of Programs
$Y_i = 1$	When program is successful
$Y_i = 0$	When program not successful
x_i	Observed value of the explanatory proposed criteria

List of Acronyms

PMO	Program Management Office
PPM	Portfolio Program Management
PM	Program Management/Manager
BM	Benefits Management
ROI	Return on Investment
CRM	Customer Relationship Management
CIO	Chief Information Officer
SAAS	Software as a Service
AIC	Akaike’s Information Criterion

Chapter 1—Introduction

1.1 Background

Decision-making and program review meetings within IT Program Management Offices (PMOs), are often contentious due to the disparate agendas of all stakeholders. Directors and executives, for example, vie for program control, while lower-level employees seek continued employment and resume building. Sometimes leadership may decide to continue the program until its "successful" completion, but it transpires that the program is no longer aligned with the organization's direction or has incurred cost overruns outweighing its benefits.

Business leaders tend to pay close attention to IT spending, especially program costs and cost overruns as these directly impact a company's bottom line. Furthermore, the popular view of the IT department as simply a cost center adds to business leaders paying close attention to the spending within IT and, by extension, a skeptical eye when looking at IT programs. The numbers back up this skepticism. For example, one 2012 study found that 45% of large IT projects and 66% of large software IT projects had cost overruns (McKinsey, 2018).

In many cases, the failure of the program is not the fault of IT Program Management Office (PMO), IT delivery teams or stakeholders. All members of the program team may work together flawlessly towards a common goal, meet every milestone, and stay under budget until the program is completed but may no longer be needed or relevant to the organization's goals and strategy. What is needed in such cases is a decision-making framework that properly aligns the organization's goals and strategy to the IT programs.

1.2 Research Motivation

As early as 1984, researchers viewed IT program selection as a significant issue. Melone and Wharton were prescient when they expressed the necessity of having an "agreed upon set of factors used to evaluate IS [Information Systems] projects…[that]... allows for an objective comparison of the strengths and weaknesses of alternative projects…" (Melone and Wharton, 1984). It is important to note that this article was dealing with project selection strategies and dealt with the decision-making process as part of the whole strategy.

In general, academic research indicates a link between decision-making models and success. Hobbs and Besner found that, "Initial planning, business case definition, team management and the use of databases are the only groups of practices that contribute significantly to the explanation of performance in the overall sample…" (Hobbs and Besner, 2016).

Another research focus discussed in section 2.2, concerns moving the perception of IT programs and IT departments as a whole from cost centers to a revenue generating or enhancing entity. One motivation for researchers exploring this shift is that IT programs can significantly affect a company's profitability. For example, the implementation of an efficient Customer Relation Management (CRM) system provides insights and reporting that allows sales to increase, an automated multi-currency payment system eliminates obstacles for paying customers, and useful collaboration software allows critical information to flow into and out of the organization more efficiently. While the decision-making process should consider program costs, assessments of their effects on revenue is often not embedded in the process.

1.3 Problem Statement

IT program management lacks an objective model for the optimal selection of IT programs that leads to the lower return on investment.

As discussed above, the decision-making process for IT program management is lacking a consistently viable model. While organizations do have some processes in place for making a decision, the objectivity of those processes would range from subjective (i.e., this is the Chief Information Officer's flagship program) to mathematical (i.e., fuzzy-variable, input/output indices, and probabilities) in order to calculate rate of success and efficiency. It is also unlikely that programs are considered in terms of providing any revenue, directly or indirectly, to the organization within those processes.

1.4 Thesis Statement

Given this problem, the question becomes: What would a decision making method within IT program management look like that is objective, accounts for return on investment and enables companies to choose optimal programs? This research proposes that:

A scoring model for the optimal program selection based on Business Capabilities, Resources, Program Dependencies and Business Value will cause an increase in return on IT program investments.

1.5 Research Objectives

Through this research, I seek to determine if such a method is possible in both theory and practice by developing a scoring model. This scoring model will be based on the academic research then tested against historical data as well as implementing the model within a Program Management Office (PMO) for actual program selection and review. This research will uniquely balance theoretical and practical perspectives.

More specifically, this research has three objectives. First, to determine how one can identity to select which IT program will have a greater return on investment compared to others. Second, identify what criteria, if any, are useful in determining program success or failure. And third, to develop a decision-making scoring model that improves the return on investment and rate of success for IT programs.

1.6 Research Questions and Hypotheses

As this research focuses on real-world circumstances, the scope of inquiry will be limited to Program Management Offices (PMOs) and organizational decision-makers and stakeholders.

The following research questions refer to the identification of criteria for use in the decision-making method; connecting the decision-making model to return on investment; and determining scoring mechanisms:

RQ1: Are there any criteria that can help with making the decision to choose the right programs for IT organization?

RQ2: What are the criteria that can help with making the decision to choose the right programs for IT organization?

RQ3: How to ensure success of IT programs will increase the overall IT return on investment for those programs?

RQ4: How to define the scoring criteria to be used for selection and prioritization of IT programs?

In response to these questions, two hypotheses are proposed:

H1: Business Capabilities, Resources, Program Dependencies, and Business Value can be used to forecast success of IT programs.

H2: A score based on Business Capabilities, Resources, Program Dependencies, and Business Value can predict success of IT programs.

1.7 Scope of Research

This research project will consist of three phases: (1) Decision-Making Scoring Model Development, (2) Historical Data Scoring Model Application, and (3) Experimental Data Scoring Model Application. It is not necessary to test the scoring model against the historical data prior to implementation as it will have no effect on the outcomes in the historical data. Therefore, the second and third phases will occur nearly simultaneously.

Phase 1, Decision Making Scoring Model Development, will include a review of the relevant literature regarding program management in order to ground the decision-making scoring model in existing theory. There are also certain details which will be based on my personal experience within PMO and the knowledge of certain aspects thereof. In such cases, it will be pointed out when they occur, and an attempt will be made to demonstrate the reason for the choices such that they will stand up to the scrutiny necessary for any academic research.

This paper will discuss Deloitte's analysis for quantifying Business Capabilities (Deloitte, 2017). While not academic in nature, Deloitte's method may offer some insight into an organization's present and potential Business Capabilities. A discussion of Business Capabilities and how they relate to IT PMOs appears in section 2.8. The possibility of using a similar business capability analysis is also discussed in light of the proposed scoring decision-making model in section 3.2.4. Based on the above, a multi-criterion scoring decision-making model is developed.

In Phase 2, Historical Data Scoring Model Application, the proposed scoring model is applied to an organization's (details regarding the organization are

discussed in the next section, 1.8) past program data to determine if the model accurately predicts the program's success. The decision to implement or continue the programs in the historical data were made using the subject organization's own decision-making model, referred to as the "Legacy Model". The purpose of this phase is to determine if the proposed scoring model would have been able to predict success or failure of the historical programs if the proposed model was in use at the time decisions were made.

Phase 3, Experimental Data Scoring Model Application, involves implementing the decision-making scoring model in the same organization. Implementation means that the decision-making model is utilized within the PMO to inform and guide the funding decisions of programs. These decisions were made in real time under the fluid decision-making environment of the subject organization. From the list of programs selected using the proposed scoring model, the success rate of the model is determined. Following the experimental data phase, a comparison is made of the resulting success rate and return-on-investment to the success rate and return-on-investment of the historical data as well as to the predicted rate (determined by applying the proposed model).

1.8 Research Limitations

It is possible that certain relevant articles are overlooked during the initial phases of the research. Accordingly, the literature has been revisited to fill such gaps in the research that became apparent during subsequent phases of the research.

The relevant literature covers a range of "perspective levels." This means that an article may address, from the narrowest to broadest contexts, project management, program management, or portfolio management. As such, there may be issues or concepts that apply to the project level but can only be applied to the program level through an aggregation of the individual projects. The reverse is also possible: there may be concepts that apply to all levels of the spectrum regardless of how they are presented.

This paper will present prior research at the same level as intended by the authors. However, where the concept is readily applied to narrower or broader contexts, the aim is to maintain the integrity of the theory or findings. For instance, findings regarding cost overruns are easily applied to the portfolio or program levels because they represent a simple aggregation of individual project overruns.

A mid-sized, Software as a Service (SaaS) corporation that provides IT and Security monitoring tools as its primary products supplied the program data to test the proposed scoring model. As such, this organization's IT department may not be typical of other industries, organization sizes, or product types. There is no reason to believe that this has any bearing on the criteria used in or the effectiveness of the proposed decision-making scoring model developed here, but further research across industries, etc. would be warranted to confirm its applicability.

The existing data covers approximately 25 months of programs. In the high-tech industry within the IT departments, this period of time should encompass enough programs and external changes to be a representative sample. Further research could explore the applicability of this model to industries where the timing requirements might be different.

1.9 Important Terms

Within the proposed decision-making model, there are several terms used that must be defined within the context of this research. The terms are more clearly defined and discussed in greater detail within the literature review in sections 2.5 through 2.8, but a brief introduction to the terms here will help clarify any confusion in the author's meaning throughout this paper.

"Business Value", in the context of this research, refers to the alignment of IT Programs with the overall goals and strategy of an organization. To have a "high" Business Value is to have a program directly relate or aid in meeting a corporate goal or strategy.

"Program Dependency" is the situation that is commonplace within Program Management where one program is so closely related to one or many other programs, that the success of the program relies on the success of that (those) other program(s). Simply put, a program is dependent on another program for success.

"Resources" encompasses all the technology, capital and, more importantly, humans with the necessary skills and knowledge to successfully complete a project or program.

“Business Capabilities” is a more abstract concept than those mentioned above, but it relates to the combination of skills, knowledge, and processes within an organization to use its assets towards growth and profitability of the organization. It is important to note that in the academic literature and the present business environment Business Capabilities are directly related to an organization’s ability to compete and bring in revenue.

Outside of the four proposed criteria, another term used in this research is “Return on Investment” (ROI). As mentioned above, enhancing Business Capabilities relates to increasing ROI, but Business Value is also a contributing factor to the ROI. In this research ROI is determined by the stakeholders of each program rather than a straightforward financial calculation and is included in the data sets, discussed later in chapter 3.1.10 Organization of Praxis

Chapter 2 is the review of relevant literature that also constitutes Phase I of the research and provides the basis for the selection of the criteria within the proposed scoring model. After the simple introduction, notes are presented in section 2.1.1 on the existing literature as well as some necessary explanations regarding terminology used.

Section 2.2 discusses the concept introduced above of viewing IT through the perspective of return on investment. Following in section 2.3, literature with project/program selection models as a general concept are discussed. Section 2.4 reviews literature in the topic of multicriteria decision analysis (MCDA) to show that while much research has been done, it is important that MCDA provide a simple, understandable method for the human involved to make a better decision faster.

Business Value is the topic in section 2.5. Business value is a way of stating, in this research, the level to which a program (can easily apply to project or portfolio as well) aligns with the overall organization's goals or strategies. The existing literature shows that Business Value is a factor important enough to be included in a program decision-making model. Section 2.6 discusses the importance of program dependency within the PMO decision-making process. Section 2.7 is a brief discussion of the literature on Resources for IT Programs.

Section 2.8 is a much longer section with the discussion regarding Business Capabilities. From existing literature, this review defines the concept of Business Capabilities, relates recent trends surrounding Business Capabilities to IT departments and underlines the importance of Business Capabilities to the business environment.

Following, section 2.9 details literature related to the uncertainty inherent in program management. Section 2.10 presents literature that relates to this research but did not necessarily fall neatly into the previous subtopic sections and section 2.11 discusses the conclusions drawn from the literature review.

Chapter 3 begins by discussing the scoring model beginning with a description of the scoring methods and how to apply the model in practice. Sections 3.2.1 through 3.2.3 then discuss Business Value, Program Dependencies, and Resources in more detail.

Section 3.2.4 then addresses Business Capabilities in more detail than the others. This is necessary for two reasons: (1) The use of the term "business capabilities" within the context of IT PMO and this research may not match what the reader would normally define the term, and thus needs clarification; and (2) Details of Deloitte's Business Capability Analysis are discussed to further illuminate (1) as well as clarification on how it relates to the proposed decision-making scoring model. The use of other business capability analyses within the proposed decision-making scoring model is also discussed.

Section 3.2.5 then moves on to details surrounding the weighting of the four factors within the decision-making scoring model. After which, section 3.2.6 discusses various other aspects of the proposed decision-making scoring model that are relevant but did not necessarily apply to the previous sections.

Section 3.3 begins the discussion on the methodology for validating the proposed decision-making scoring model. Section 3.4 discusses the data analysis tools and 3.5 gets into the methods used to analyze the data which includes Binomial Logistic Regression and Random Forest testing. Binomial Logistic Regression is used by applying the model to a selected list of programs to determine the model's validity before and after application.

Chapter 4 examines the results of the research based on the decision-making model's predictions with the historical data followed by the results of the experimental phase.

The paper concludes in chapter 5 with a discussion of implications, including the research's applicability and contributions to the body of knowledge surrounding IT PMO research, and, finally, with recommendations for further research.

Chapter 2—Literature Review

2.1 Introduction

This literature review is organized by topic so that it can be directly related to the proposed decision-making model and the analysis thereof. Each section will deal with a specific criterion within the model, decision-making models in a more general sense, and other topics related to the model.

A subsection of this introduction that follows includes important notes regarding the existing literature and this literature review itself. It will provide some background information that should clarify any areas that may have caused confusion without it.

Section 2.2 reviews the literature surrounding evaluating IT from a return on investment perspective which is a key concept in this research followed by section 2.3 that discusses the literature regarding project/program selection and review models in general. The purpose of which is to provide a basis that selection and review models are beneficial in the selection and review process. Section 2.4 reviews literature in the topic of multicriteria decision analysis (MCDA) to show that while much research has been done, it is important that MCDA provide a simple, understandable method for the human involved to make a better decision faster.

The following sections review the literature covering the four factors of the proposed scoring model. Business Value, covered in section 2.5, is a way of stating the level to which a program (can easily apply to project or portfolio as well) aligns with the overall organization’s goals or strategies. The existing literature shows that Business Value is a factor important enough to be included in a program decision-making model. Section 2.6 discusses the importance of program dependency within the Program

Management Office (PMO) decision-making process. Section 2.7 is a brief discussion of the literature on Resources for IT programs.

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Following, section 2.9 details literature related to the uncertainty inherent in program management. Section 2.10 presents literature that relates to this research but did not necessarily fall neatly into the previous subtopic sections and section 2.11 discusses the conclusions drawn from the literature review.

2.1.1 Notes Regarding Existing Literature and Literature Review

The existing literature has dealt with the issues surrounding IT program management from many perspectives, including those of return on investment, project or program selection development, review models, and the risks and uncertainties of project and program management.

There exists in the literature several articles that apply to Program Management Office (PMO) but do not have the decision-making process or models as the focus of their research. For instance, Howell et. al. (1998) argues for the portfolio perspective to be applied to oil and gas industry corporate financial decisions. Also, scholars such as Savelsbergh et.al. (2016), Jacobsson and Hällgren (2016), and Joslin and Müller (2016), have dealt with the overall organization of Program Management Offices. Some of these articles are worth noting how they relate to the decision-making process in that they represent risks outside the scope of a decision-making model.

IT Governance, in particular, can represent a significant risk to the success of some or even all programs carried out within the organization. IT Governance should include objectives such as, “Alignment of IT with the enterprise and realization of the promised benefits, use of IT to enable the enterprise by exploiting opportunities and maximizing benefits, responsible use of IT Resources, [and] appropriate management of IT-related risks” (Iliescu, 2010).

A truly exhaustive literature review relating to project, program, or portfolio management would require a Herculean effort given the broad range of sub-topics possible. Although many subtopics may only peripherally relate to decision-making models within IT departments, these limited connections can often provide insights. For instance, the Iliescu (2010) quote given above is from an article concentrating on auditing IT governance but relates to viewing IT programs from a return on investment perspective. Another subtopic that may have insights useful for decision-making is Business Capabilities. This subtopic is discussed in detail within this literature review but prior to this research, to the author’s knowledge, Business Capabilities have not been directly related to a decision-making model previously.

This literature review describes the academic research that led to the development of the decision-making scoring model this paper theorizes. As stated in the introduction, this research project combines the academic and practical (practices, tools, and commercial sector services) knowledge to solve the problem presented. In keeping with traditional dissertation organization, discussion of “commercial” literature will be postponed until section 3.2.4 (Business Capabilities) when they become relevant.

It is necessary to take note of some terminology used in the literature and how it relates to this research. The level of perspective varies greatly between papers. “Level” refers to the scope of the research being discussed within a particular article. Papers approach issues from the project, program, or portfolio level, to name them from the narrowest to the broadest perspective. This variation presents a challenge when providing outside support for conclusions. Although much of the research is applicable across the full range of perspectives, others may only apply to one specific perspective. An example of this is Laslo’s article, “Project portfolio management: An integrated method for resource planning and scheduling to minimize planning/scheduling-dependent expenses” (2010). As indicated in the title, the level of perspective of the research is at the portfolio level and the nature of the research is such that it can only apply when viewing an entire portfolio of projects, not just one. This literature review will discuss the literature at the level of perspective found in the specific article being discussed and discusses its applicability to other perspective levels.

2.2 Evaluating IT from a Return on Investment Perspective

One aspect that many methods do not consider is how the project or program or portfolio selection relates to return on investment. Cost, of course, is always a major component, but from a budgetary perspective: can we afford it or not? Through the course of reviewing the literature, we were unable to identify any research considering potential revenue from portfolios or programs. When the IT PMO spends its budget, it is not granted a credit from the revenue the sales team brings in by the programs it carries out. Furthermore, such considerations could only be speculative and could introduce more subjective factors into the decision-making process.

There are some articles that argued for program evaluation considering the return on investment for the organization to be discussed in detail in this section. That is to say that the IT department and its projects or programs should not merely be viewed as a "cost center" (Quartel, et. al., 2010) but as a direct or indirect revenue stream.

Many articles concur that changing the perception of IT as a cost center would require aligning IT goals with that of the organization. While the details of how to accomplish this alignment vary by author the overall view is that "...companies need to align their IT investment decisions with overall company strategy and business objectives" (Häckel, et. al., 2014).

Although Häckel et. al., among others, limits his approach to aligning IT decision-making with other decision-making processes outside of IT within an organization, Quartel et. al. takes it a step further. As mentioned above, these methods move beyond the "cost center" mentality, which concentrates on the indirect benefits of IT projects and or programs, and instead regard the IT department as a revenue-producing area within the organization. Scholars propose various methods to integrating IT Program Management into the decision-making process, but they largely concur that there will always exist an aspect that must concentrate on "operational efficiency [and] minimizing risks [that] is not related to business strategy" (Quartel, et. al., 2010)[1].

Meanwhile, some scholars advocate applying project, program and portfolio management methods to other areas of the organization to improve the return on investment from those areas. One such study found that employing portfolio management

[1] Quartel et. al. is here referring to a paper by Venkatraman that identifies four sources of value from IT, including the "cost center" source. As of the date of this paper, that original source has not been located so the secondary source is cited in its stead.

methods within the area of product management, increased the product portfolio's "innovativeness" (Urhahn, 2014). This study suggests that the portfolio management approach contains the necessary structure to align whatever department is under scrutiny to the organizational strategy and goals.

2.3 Program Selection and Review Models

The literature on the general topic of project and or program selection and review models is both abundant and varied. Each article proposes its own methods for identifying which factors are important and attempts to create a framework that prevents subjective factors from taking over the selection and review process. "Subjective factors," here refers to aspects such as the political, relational, and other ulterior motives that exist within any organization and that can have an influence on the decisions made.

The different methods proposed fall into several different categories to eliminate the subjectivity of the selection decision making process. Wen and Shih (2006) discuss several of these categories for prioritizing IT investment including, using their names for the categories, Ratio Methods, Real Options, Mathematical Programming Methods, Decision Theory Methods, and Scoring Methods. Wen and Shih go on to identify Scoring Methods as the optimal method given the advantages of its "generally higher ease of use and lower cost performance than the other methods." In addition, Wen and Shih argues that scoring methods, "are the only methods specifically designed to incorporate non-economic criteria" (Wen and Shih, 2006). Examples of what constitutes non-economic criteria and its importance are presented later in sections 2.5 through 2.8.

In one of the earliest articles specific to project selection in an IT environment, Melone and Wharton (1984) lament at the lack of academic attention to IT project selection. They argue for an "agreed upon set of factors used to evaluate IS [Information Systems] projects… [that]...allows for an objective comparison of the strengths and weaknesses of alternative projects…" (Melone and Wharton, 1984). It is important to note that the article was dealing with project selection strategies and dealt with the decision-making process as part of the whole strategy. Thirty-five years after the publication of Melone and Wharton's article, researchers are still looking for that "agreed upon set of factors" or, in other words, a decision-making model.

In general, research indicates a link between decision-making models and success. Hobbs and Besner (2016), for example, found that, "Initial planning, business case definition, team management and the use of databases are the only groups of practices that contribute significantly to the explanation of performance in the overall sample…" Of these practices, initial planning and business case definition, are particularly relevant to this research. Initial Planning "contains the tools and techniques required to produce 'Project schedule and plans'…"(Hobbs and Besner, 2016). Initial planning can be easily interpreted as part of decision-making process for programs.

Business case definition is clearly related to decision-making models. According to Hobbs and Besner, business case definition, "includes needs analysis, business opportunity, problem definition, project mission statement, [and] assign[ing] project sponsor…" (Hobbs and Besner, 2016). They also note that the Project Management Institute views business case definition as external to projects and is dealt with prior to project initiation as part of the decision-making process.

Some research have applied a very heavy mathematical approach to the decision-making process. A few are discussed below but others include Razi and Shariat (2017) and Toppila and Salo (2016). These methods designate certain categories or criteria to assess and assign a score. These figures are then run through a mathematical model that produces an output score, value, or rate, which determines the fate of the project, program or portfolio.

Various methods attempt to account for the inherent uncertainty in program and portfolio management (this uncertainty is discussed in more detail in section 2.9). Some methods go as far as to use fuzzy variables to provide a built-in uncertainty factor within the mathematical model. Ghapanchi (2012) proposes one such model that includes “the usage of input/output indices to measure risk, interaction between project and fuzzy variables and with associated probabilities to be used as criteria to calculate rate of success and efficiency per project” (Ghapanchi, 2012). The inherent problem with the use of heavy mathematics, such as Ghapanchi’s method, is that it assumes familiarity with statistical and mathematical modeling on the part of the decision maker. Without understanding how an output was determined, one is unlikely to grasp the full implications of the output.

Further complicating the use of mathematics in decision-making models, there are questions in the literature whether available data is adequate for portfolio decision-making models. Ardren (2008) suggests that the data collected and report creation along with other factors, creates a situation that any portfolio management is rendered ineffective. In effect, Ardren suggests that the data available and report creation (along with other factors) does not provide information that is useful for making decisions in the area of portfolio management. In the case of using mathematically heavy decision-making models, the input data would not represent an adequate model of the current state of affairs.

There also exists a study by Pedersen (2016) that examines whether experienced portfolio managers use decision-making models. The findings by Pedersen, although limited by the small sample size, indicates that experienced portfolio managers rely on factors such as “Politics, Experience and Good Friends” rather than relying on the output of decision-making models. This research concludes that an experienced portfolio manager will make choices using factors such as the political environment surrounding the portfolio, how their past experiences in similar situations relate to the current portfolio, and what their network of associates have to say regarding the situation. The resulting decisions, whether correct or not, become very subjective if this is the case and portfolio success is reliant on that one individual’s ability.

Pedersen’s findings might be troubling for the prospect of creating decision-making models if, in fact, they are not used by the intended audience. However, Pedersen does not see the findings as an argument against modeling. Rather, he maintains that the resulting insights from his research “can be used by practitioners to identify possibilities for improving IT project selection in a systematic way.” The implications of this research relate to the overall structure and running of a Program Management Office (PMO), which is beyond the scope of this research.

Ghasemzadeh and Archer sum up the short comings of prior attempts to formulate a decision-making process in this way:

> *Among published methodologies for project portfolio selection, there has been little progress towards achieving an integrated framework that: (a) simultaneously*

considers all the different criteria in determining the most suitable project portfolio, (b) takes advantage of the best characteristics of existing methods by decomposing the process into a flexible and logical series of activities and applying the most appropriate technique(s) at each stage, and (c) involves full participation by decision makers. (Ghasemzadeh and Archer, 2000)

Ghasemzadeh and Archer here identify the three main characteristics a decision-making process should possess. While (a) and (b) are the characteristics much prior research has attempted to address, the academic research seems to pay little attention to (c). Decision-making processes necessarily involve the decision-makers as active participants in the process that must be understandable and useful to them.

2.4 Multicriteria Decision Analysis

Program management decision-making involves several criteria. A good deal of literature regards multicriteria decision analysis (MCDA) in a variety of contexts. For example, computer networking infrastructure (Brooks and Kirkwood, 1988), oil and gas transportation (Tavana, Sodenkamp, Pirdashti, 2010), ecological risk management (Fanghua and Guanchun, 2009) and natural resource management (Hajkowicz, McDonald, Smith, 2000).

Often, the literature addresses multicriteria decision analysis through complex mathematical modeling. Liesiö (2014), discusses the underlying assumptions involved in such modeling and presents a way to change one of those assumptions. The details of Liesiö's findings do not directly relate to this research, but the research surrounds non-additive criteria. As Liesiö defines it, additive criteria are criteria where the "portfolio value is the sum of additive multi-attribute project values" (Liesiö, 2014). Liesiö's research shows that it is necessary to not assume a portfolio's score in a particular criterion is the sum of the score from the constituent projects. It is important to be certain that a particular criterion for a portfolio is simply an aggregation of the individual project criteria scores.

The literature suggests that making decisions based on multiple criteria adds a layer of complexity that can create difficulties in the decision-making process for the decision maker(s). While various algorithms can be applied to make sense of and organize the data in order to make it actionable, a complete understanding of each step along the way as well as the input and output may be necessary for proper interpretation.

Some scholars have studied how the representation of data affects how decision-makers make choices. For example, Killen (2017) found that, "Methods that enable decision makers to better understand information in less time will reduce the effect of the "bounded rationality" that limits decision quality. " While her research deals primarily with the graphical representation of program interdependence, it is applicable to this aspect of multicriteria decision analysis (MCDA). Her findings suggest, as she states, "Methods that enable decision makers to better understand information in less time will reduce the effect of the "bounded rationality" that limits decision quality" (Killen, 2017)

The research suggests that the key to MCDA is the clarity of the criteria and associated data to those charged with decision-making as well as the ability of those criteria to be predictors of success or failure. The literature involving MCDA identifies several criteria that should be included within IT portfolio management decision-making model and are discussed in sections 2.5 through 2.8, following.

2.5 Business Value

An aspect that receives significant focus within proposed business models is alignment with the overall business goals or strategy. Smith and Sonnenblick (2013) provide some empirical evidence that such alignment can provide benefits for the organization. While this study focused on R&D projects for one particular pharmaceutical company, it showed how such a shift towards selecting a set of projects with an emphasis on company strategy can alter the entire decision-making process. Rather than recreating an entire portfolio decision prioritization process, the head of the portfolio management group inserted strategy alignment as a significant factor in the final decision.

The other significant point of the study was the decision to shift the focus from the project level to portfolio level. The leadership "believed that funding the 'best' projects would get them the 'best' portfolio". Rather than concentrating on which projects are performing or fall within the optimal metrics, the company looked towards selecting a portfolio of projects that aligned with the company strategy. This approach clearly points to the fact that an organization cannot apply an abstract corporate strategy to the low-level specifics involved in one particular project. Only a portfolio of projects, headed in a general direction or towards a goal, can apply to a strategic direction.

Urhahn and Spieth (2014), from a different direction, arrive at the same conclusion regarding alignment with corporate strategy. Their study focuses on the governance of the portfolio management process and how that relates to the innovativeness and success of the organization. Urhahn and Spieth find that governance must be organized to align with corporate strategy in order to provide the necessary level of innovativeness to be successful.

Kamogawa (2010) confirmed these findings, showing that, “Including IT governance in internal control is more likely to improve the capability of an organization.” Kamogawa uses the term capability in a different way than is used later in this review. He uses the term to refer to “the ability to design a business strategy,” as opposed to the definition of Business Capabilities discussed in detail in section 2.8 of this literature review.

Another perspective on Business Value in portfolio management comes from Bucher and Min (2017), who provide a framework for evaluating portfolios in the U.S. Government Space Industry. They propose several metrics to evaluate portfolios within the industry including what they refer to as Capability which they define as, “the alignment between a portfolio of functional elements and an organization’s objectives and/or strategic goals.”

While Bucher and Min are not proposing a decision-making scoring model, they do propose a perspective for the evaluation of elements from the enterprise level to the individual project level to ensure they align with the objectives or goals at each level. Each level’s objectives are based on the level above and the role it plays in the larger perspective. The point is to ensure the portfolio is relevant to the business as a whole and adds value.

Business Value has been discussed in connection with project and portfolio management using various terms. Benefits management and value management are the terms most recently associated with project and portfolio management. Laursen and

Svejvig (2015) assert that as early as the 1940's, research on value management has been presented but, "it very often meant reducing capital cost rather than focusing on the nominator, i.e., increasing benefits and thereby enhancing value." In the 1980's and 90's benefits management research began to focus on IT spending in terms of return on investment and alignment with organizational strategy.

2.6 Program Dependencies

Although the literature largely regards program dependency as simply a factor in the decision-making process, Cho and Shaw (2013) suggest that interdependence between projects can be risky. For instance, if one major project is closely related to a small, minor project, the seemingly insignificant failure of the minor project can lead to the failure of the major project. However, interdependency also has benefits in terms of planning and grouping individual projects into programs or portfolios, interdependence is assumed as they work towards a common end. A group of projects under a common end would necessarily have some overlap.

Killen (2017) sums up the importance of interdependence, stating , "The interdependencies [when projects depend on each other to be successfully executed] between projects add to the complexity of Portfolio Program Management(PPM) decision-making and must be considered along with financial, strategic, risk, resources, and other factors."

The interplay of projects and programs is a key aspect of portfolio management, which the literature does not fully account for in decision-making models. Several papers mention program dependency, including Sampath et. al. (2015) but attempts to account for program dependency are forced to deal with the interdependency as a side issue in the decision-making process. Sampath, et. al.'s solution is to provide visual information in order to aide senior management who have "a wealth of business intuition" to more readily make decisions based on intuition rather than on built-in criteria.

Although the senior managers at Intel (the company which was the focus of Sampath's research) may be quite adept at using their intuition to achieve positive results, not all companies may possess such skilled senior management. Therefore, decision-making scoring models should not rely on the ability of senior management. One of the attempts to lessen the reliance on the ability of senior management is the model created by Ghapanchi, et. al. . Using mathematical modeling with fuzzy numbers in an attempt to account for uncertainty and Program Dependencies, they develop quite a complex model. While complexity should not be considered problematic in itself (further discussion of this point below), usability is also critical. If every senior manager involved in the decision-making process for IT programs had an extensive mathematical background, the proposed model may be adequate. However, with senior executives and other management with business credentials leading IT and its underlying functions, the heavy use of mathematics in the decision-making process may be unrealistic as discussed earlier in section 2.3.

2.7 Resources

The availability of Resources is largely ignored within the literature regarding scoring models unless the model is developed to specifically deal with resource availability. It is even the case that resource availability is specifically excluded from the decision criteria, such as in the case of Padovani and Carvalho's article (2016), which focused on the overall structural model of portfolio management. They separate out resource allocation as a separate process which occurs during the "prioritization step." Ultimately, the available Resources do play a role in the ultimate decision of whether a project moves forward but is not present within the decision-making model itself.

There are several articles directly addressing resource allocation for project and portfolio management, including Padovani and Carvalho (2016). Most regard Resources as an external determinate in the decision-making process, as if the selection decision to move forward with a project should be made then the Resources found to accomplish successful program. As an example of this perspective in the literature, Laslo (2010) notes that, "In a multiple-project situation the vast majority of projects share Resources with other projects and thus the major issue is to find a way of handling resource scarcity according to the overall strategic direction of the corporation." Laslo then develops a resource allocation method that assumes existing projects should only be deprioritized in terms of resource allocation if they do not align with the "strategic direction of the corporation."

2.8 Business Capabilities

The concept of Business Capabilities when used in everyday speech, there appears to be a loose understanding of what one is referring to. However, that loose understanding may not contain the entirety of what the theoretical concept encompasses rather it may be limiting the answers one gives in response to questions that arise regarding it.

Day (1994) offers this well-articulated theoretical definition, "Capabilities are complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets."

In other words, Business Capabilities refer to a combination of skills, knowledge, and processes within an organization. Through the combination of these three parts, an organization uses its assets towards some end. An organization's processes are what allow those skills and knowledge to be applied towards the desired end. It is the organizational equivalent to an individual's abilities. Day (1994) also discusses the difficulties associated with management's ability to identify and quantify these capabilities. He suggests a method of identifying the capabilities in an organization. Namely, as the capabilities are "deeply embedded within the fabric of the organization," an organization should "create detailed maps of the sets of process activities in which the capabilities are employed (Hammer and Champy, 1993). These maps usually show that capabilities and their defining processes span several functions and several organizational levels and involve extensive communications" (Day, 1994).

The process aspect of Business Capabilities has been the focus of much literature as well as commercial products and services. Given that skills and knowledge are a function of hiring the right talent (as well as collecting, accessing and disseminating institutional knowledge), organizations are already equipped to deal with this aspect of Business Capabilities through recruitment. However, processes can be more difficult to develop, change and review within an organization.

Articles and books such as Thomas Davenport's "Process Innovation: Reengineering Work through Information Technology" examine how to bring about innovation in processes, to allow for "order-of-magnitude levels of improvement in these processes," which Davenport argues is necessary to stay competitive in the modern business environment (Davenport, 1992).

Davenport's book provides a salient definition of what exactly a process is in this context. He defines a process as "...a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action."

Prior to and since the publication of Davenport's book, this concept of business processes has been expanded to be an organizing principle for entire organizations. It appears that this is not necessarily a topic or principle within the academic realm so much as it is within "popular media" or for business consumption. Sussan and Johnson (2003) presented evidence that moving into such a "business process orientation" offers significant return on investment.

Wu and Chen (2014) had similar findings when attempting to "define a model to properly evaluate knowledge management value". They found that "Knowledge assets and process capabilities have emerged as the most strategically important knowledge Resources of the organization, as they can be further integrated to create new business processes and then achieve superior performance outcomes."

More specifically to IT departments and how they relate to Business Capabilities, it has been observed that IT has moved beyond acting as a support role for business organizations and within business processes. Chan (2000) calls for IT to be viewed as playing three distinct roles: Initiator, Facilitator and Enabler. As an initiator, IT "would act as an agent of change," where existing technology presents new ways of utilizing it or even the need for new business processes to support new technologies. As a Facilitator, IT "may serve as something to make work or a workload easier." It is when IT innovates business processes that it acts as an Enabler. "IT is designed to accelerate specific process steps" and thus is in a privileged position to have the greatest impact on Business Capabilities.

Further evidence of IT's special connection with Business Capabilities is discussed throughout the literature. One research project that carried out an extensive literature review combined with a survey found, among other things, a direct connection with IT projects and business processes. In part, they concluded that:

> *In IT deployment projects, business process issues need to properly managed, or vice versa. As is often discussed in the literature, IT deployment without process amelioration might be a waste of opportunities for efficiency gains and IT investment* (Law and Ngai, 2007).

This connection intertwines IT projects with Business Capabilities in such a way that the two seemingly cannot be fully separated. Due to this, consideration of Business Capabilities (the skills, knowledge and processes of an organization, by Day's definition) must be present in any decision-making model for it to be applicable in the real world. Putting the consideration off to a step outside the model would be to ignore the elephant in the room. A project or program rolling out a new tool would fail in the long run if there did not exist, or the necessary skills and knowledge weren't present to implement, a process to take advantage of that tool and overarching goal to enhance the organization capabilities to stay competitive.

2.9 Uncertainty

While all of the above literature focuses on very real and very important aspects of project and program management, a theme runs through nearly all not centered on the problems as a purely academic issue. That is that there exists a strong uncertainty factor related to project and program success. Much of the literature attempts to account for this using statistical methods while others simply accept it as inherent from the outset.

As Petit (2012) points out, some authors attempt to deal with this uncertainty factor by developing methods and processes in the realm of risk management. He goes further than this stating that risk management infers a concentration on events rather than a species of risk that are “Unknown-Unknowns (Unfathomable uncertainty)”. He and other authors then refer to uncertainty management as a better perspective for dealing with risks and uncertainties present in portfolio management.

Richardson (2016) identifies three primary reasons for the failure of project management and project management offices in tech-driven companies as (1) lack of support from senior management, (2) poor scope management, and (3) lack of clear prioritization. The importance of this article and others like is to support the notion that even with the perfect scoring model in place for a particular organization, there are uncertainties and other factors that can undermine the effectiveness of the model and the organization’s project and program management in general.

Given the above, it seems necessary to point out that any decision-making model for projects and programs cannot be expected to account for every possible factor that can have an effect on project and program success. Models take criteria at a particular point in time and compare them within the same environmental context. Program Management Office (PMO) must use other processes to assess risks and plan accordingly using, for example, constraint management processes (Worley, 2005).

Part of dealing with this uncertainty factor is the regular review of projects and programs using the scoring model. The changes over time of the scores for individual programs helps to account for the uncertainty factor by taking another snapshot in time. Changes may occur, both positively and negatively, that affect the available Resources, Program Dependency, the Business Capabilities and the Business Value. Once outside forces detrimentally affect the score(s), the model may show that the affected program should no longer be pursued, and the company's losses cut at once. Without a scoring model to compare the program to over time, it is possible that programs could continue under its own inertia.

Secondly, the literature points to a confounding of complexity and uncertainty. Padalkar and Gopinath (2016) performed a semantic study of the two terms within project management literature and found that this, in fact, was the case. It is important that the complexity of project and program management to not be confused with the uncertain factors. Often times a program, or certain large-scale projects, can be so complex that modeling it seems to be beyond the scope of any decision-making scoring model. The difficulties in making these situations fit into a model does not necessarily add uncertainty to the decision-making process but rather add time and effort.

Any decision-making model, and especially scoring models, may have a level of uncertainty when assigning the necessary scores for each attribute. Attempts have been made to account for such uncertainty through various algorithms to select the proper program where uncertainty does exist within the scores. Toppila and Salo (2016) developed one such algorithm based on binary decision diagrams in order to account for the uncertainty across portfolios. Their method is based on the idea of a "non-dominated portfolio." A non-dominated portfolio is a "portfolio such that it is not possible to select another portfolio which has (i) at least as high value with respect to every attribute for all plausible scores, (ii) and has strictly higher value with respect to at least one attribute for some plausible scores.” .

In short, when dealing with uncertain scores, the algorithm attempts to choose the portfolio that does not have better certainty and equal scores across all attributes and does not have a higher value for one attribute, all else being equal. While this algorithm can be useful in such scoring models using complex mathematical scoring, the algorithm could add an unnecessary level of complexity to more simplified scoring models. The point is to underline that complexity will always be present in project, portfolio and program management, but it is necessary to separate that from uncertainty where tools and processes exist to deal with it.

2.10 Other Related Literature

As mentioned at the beginning of this literature review, there exists much literature not directly related to the purpose of this research but may provide some insights or perspectives important to it, nonetheless. One such topic relates to *Benefits Management* (BM). BM can be defined as “the initiating, planning, organizing, executing, controlling, transitioning and supporting change in the organization and its consequences as incurred by project management mechanisms to realize predefined project benefits” (Badwei, 2016).

There is much literature on BM in connection with project, program and portfolio management but rarely with any significant results. One study was conducted by Amgad Badwei attempting to find if a BM or project management framework, or a combination of the two, has a significant impact on success. His findings included that BM has a significantly lower impact than project management frameworks. He did, however, find that organizations implement both do have significantly higher level of success.

Badwei's findings point to a fact that has been on the periphery of the literature review throughout. A decision-making scoring model in regard to portfolio management is an extremely important factor in maximizing an organization's successful portfolio management.

The existing literature also contains evidence that multiple decision-making methods are necessary within a single organization to ensure the proper level of flexibility in choosing different types of projects. This stems from decision-making theory's view that "it is not always possible for people to make decisions in a pure rational way" (Gutiérrez and Magnusson, 2014).

Gutiérrez and Magnusson's research investigated the issue with legitimacy in having multiple decision-making methods in one organization and found that it depended on the ability of management to "legitimize" the alternative methods. While this may be more directly applicable to programs related to product development rather than IT programs, it does raise questions as to whether or not multiple methods would be useful.

2.11 Summary and Conclusion

The volume of literature surrounding portfolio management decision-making methods attests to the importance of the topic. Much research has been done in determining the best possible solutions to the smallest details in the subject. The research discussed here does not take into account the literature, services and conventions devoted to the topic in the commercial arena which may increase the volume by an order of magnitude.

A shift towards viewing and making decisions based on a Return on Investment perspective for IT has become more evident in the more recent literature. Researchers argue for considering the IT department as a whole along with the IT's projects and programs, as a potential revenue generator or enhancer. Viewing project portfolios from this perspective allows decision makers to tie the IT department to the potential revenues of the organization rather than simply as a cost-center. With the return on investment for IT, a shift is made in the definition of project and program success to include corporate strategy and revenues as part of what it means to be successful or not.

Decision-making models have been identified as necessary in the literature for at least 35 years. Over that time, there have been a large number of decision-making models proposed, all necessarily centered on a multicriteria decision analysis approach, with varying levels of complexity. The nature of the criteria within the decision-making process includes noneconomic data and, as such, a scoring model works best in modeling these factors. These various decision-making models also attempt to account for the uncertainties inherent in portfolio management and decision-making models themselves.

Nearly every model identified criteria different than the models that preceded it leaving any researcher or practitioner with a large list of criteria to choose from. This literature review was able to identify several criteria that are significant in predicting project and program success according to the research present in the literature: Business Value, Program Dependencies, Resources and Business Capabilities.

As shown in the discussion on return on investment (ROI), alignment with business strategy and goals is a necessary step towards providing ROI from IT projects and programs. Business Value is the extent to which a project and program aligns with those goals. Resources and Program Dependencies are dealt with, to varying degrees of detail, within the literature quite extensively. However, Resources and Program Dependencies are quite often overlooked or side-stepped with regards to decision-making models within the literature. Both are treated as outside the context of the decision-making model or as a step before or after the scope of research.

The concept of Business Capabilities as “complex bundles of skills and accumulated knowledge, exercised through organizational processes” (Day, 1994) has existed in academics and related research for at least twenty years. During that time, the concept has made its way into the commercial arena and has become an organizing principle for many organizations. Business Capabilities has then come to be part of all aspects of an organization, including IT. As such, IT and its associated projects and programs come to play a role in the improvement of those Business Capabilities. It is then necessary for the decision-making model selecting and reviewing IT projects and programs to take its affect on an organization’s Business Capabilities into account.

It is interesting to note that the literature, especially more recently, has tied an organization’s Business Capabilities closely to the IT portfolio management. Not only must the processes that combine with the skills and knowledge to be considered when applying changes through IT, changes in those processes must also account for the IT aspects. This shift puts IT squarely in the center of an organization's change management.

As such, the decision-making models used within IT portfolio management take on a renewed importance. Wasted time, investment, and Resources can be critically important in the fast-paced business environment of today as they have an impact on an organization’s revenue. This fact can at least partially account for the amount of literature on the subject.

Another key aspect of program management is the level of complexity that is inherent in the discipline. When dealing with multiple criteria in a decision-making model, countless variables are outside of the scope of the model such as organizational and economic factors which will add more complexity to the decision-making process. The existing relevant literature seems to point to the fact that complexity is not necessarily equivalent to uncertainty despite much of the literature treats it as such. Allowing for the uncertainty which comes with that complexity need to be built into the decision-making model in some way. Many of the highly mathematical methods in developing models will use probability and other tools to account for the uncertainty while other methods may be used.

Chapter 3—Methodology

3.1 Introduction

As part of the methodology of this research, the details of the scoring model, underlying rationale for the scoring, and weighting of those scores are discussed. Included in this section is a lengthy discussion regarding Deloitte's Business Capability Maturity Assessment process. This process is important to the overall praxis because of the central role it plays in the scoring model. While Deloitte's product is not a necessary part of the model, similar capability maturity assessment is necessary in order to identify the organization's capabilities and areas of needed improvement. Further discussion of this point can be found below.

Details are also presented on the methods used to test the scoring model against actual program data. Included are the details of the statistical models used to gain further insight from the data.

3.2 Proposed Scoring Model

The proposed scoring model is intended to be simple enough that decision makers can use it without any training but still be a powerful tool in the decision-making process. Through a review of the relevant literature, we found that Program Dependencies, Resources, Business Value and Business Capability are the key factors in determining program success.

The next step was to develop a scoring model that took these factors into account and placed them in their proper relative importance to one another. A broad description of the model and how it would be used is described here followed by more detailed explanations of the four factors and the rationale behind the weights assigned to them.

Two factors, Resources and Program Dependencies, are scored in a binary manner. That is to say they are a yes/no or 100%/0% value when assigning a score. Business Value consists of a scale of percentage values based on the type or category of values the program offers to the organization. Business Capabilities is also assigned a percentage values but is based on the scores determined through Deloitte's business capability which will be discussed in greater detail later in this section.

Once percentages are determined for each category, the percentages are then multiplied times the Overall Method Weight to determine that factor's Final Score. The four Final Scores are then added together to determine the program's Total Final Score. Due to factors discussed below, the highest Total Final Score a program can receive is 100 and the lowest possible is a 12. See Table 3.1 below for a graphical representation of the scoring model.

Table 3.1 - Scoring Model Weight and Scoring Details

Scoring Criteria	**Overall Method Weight ***	**Score Drilldown ***	**Final Score Calculation (Overall Prioritization Method Weight * Score Drilldown)**
#1 - **Business Capabilities Scores from and to**	40	Diff From to 0.1 -0.5= 10% 0.6-1=20% 1.1-1.5=30% 1.6-2.0= 40% 2.1-2.5=50% 2.6-3.0=60% 3.1-3.5=70% 3.6-4.0=80% 4.1-4.5=90% 4.6-5.0=100%	**Max Score** = 40 * 100% = **40** **Min Score** = 40 * 10% = **4**
#2 - **Resources (skills and capacity)**	24	Skillset Availability (Y/N)	**Max Score** = 24 * 100% = **24** **Min Score** = 24 * 0 = **0**
#3 -**Program Dependencies**	20	Programs dependencies (Y/N)	**Max Score** = 20 * 100% = **20** **Min Score** = 20 * 0 = **0**
#4 -**Business Value**	40	Revenue efficiency= 40% Compliance Impact = 30% Operational efficiency = 20% Legal Impact = 20%	**Max Score** = 40 * 40% = **16** **Min Score** = 40* 20% = **8**
TOTALS	**124**		**TOTAL MAX =** 40 +24 + 20 + 16 **= 100** **TOTAL MIN =** 4 + 0 + 0 + 8 **= 12**

Once all programs have been scored, then it is a relatively simple manner to compare them with their relative possibility of success/viability. Based upon the relative ranking of programs, decision makers should be able to see which programs to fund or not.

The Total Final Scores can also tell the decision maker if any programs should be funded or if they need to revisit the entire portfolio. A Total Final Score of 100 does not mean that the program is the best to choose from, given the list of possibilities, but rather that it has a high chance of success. If the entire portfolio is made up of low scoring programs, the causes should be investigated.

3.2.1 Business Value

Business Value is a factor which brings the Return on Investment (ROI) perspective into the decision-making process in a rigorous way. Within IT departments, it is extremely difficult and problematic to place a dollar amount on the benefits derived by any program. Increased efficiency, better internal communication, or improved customer experience, to name a few, are simply factors that combine with others to increase revenue.

It is then necessary to take a broader view of ROI and separate out classes of activities and their potential impact on revenue. These are, in order from the most revenue enhancing to the least, Revenue Efficiency, Compliance Impact, Operational Efficiency, and Legal Impact.

Revenue Efficiency refers to programs that have a large effect on productivity efficiency or directly leads to revenue generation. These are the programs that will reduce costs by saving man-hours or provide new capabilities to the workforce which allows the organization to do more with less cost or brings in revenue from outside by providing extra services directly to the customers. This is obviously the ideal when approaching programs from an ROI perspective and thus is the highest scoring category within Business Value.

Compliance Impact refers to the large-scale, must do programs relating to regulatory concerns or security issues. An example of such a program in recent history would be the implementation of the European Union’s General Data Protection Regulation (GDPR) which required organizations doing business with European Union citizens to adhere to a long list of data security, sharing and reporting requirements (Regulation (EU)2016/679, 2016). These programs are the type which an organization must undertake to avoid considerable penalties, being shut out of markets, or other potentially catastrophic consequences. These are essentially “do or die” programs that can have detrimental effects to an organization's revenue in many different aspects. This category is rated below the Revenue Efficiency because of its negative nature: an avoidance of revenue losses rather than revenue enhancement.

Operational Efficiency and Legal Impact are meant to encompass the aspects of IT that will always exist and relate less to revenue than to the cost center perspective. Operational Efficiency relates to the maintenance and updates of technology while Legal Impact relates to the low-level, operational programs that come from minor changes to human resources and legal regulations or requirements.

3.2.2 Program Dependencies

Program Dependencies is one of the two binary scored factors in the scoring model. This is due, in part, to the incredible difficulties with scoring the various levels of dependencies that can exist between programs. The dependency can be based on the use of technology between the programs or upon the resources (manpower) needed. The dependency can also take the form of both manpower and technology.

As such, attempting to calculate a score accounting for all the possibilities of dependency would require a level of analysis and complication that defeats the overall goal of simplicity for the proposed scoring model. The scoring model then simply identifies if any significant dependencies exist with a yes/no answer. A "Yes" represents 100% while a "No" represents 0%. Given the fact that dependency on other programs can add synergy in technology or resources as well as risk it is good to be highlighted with a higher score to add visibility.

3.2.3 Resources

The second of the binary scored factors is Resources. The intricacies involved in developing a non-binary score for this factor would reduce the effectiveness of the overall scoring model. The Yes/No nature of the Resources factor simply signifies if there are sufficient Resources with the right skill set for the program.

The emphasis is placed on the availability of the skill set rather than just workforce. While there are models that do account for the availability of Resources, the approach is most often based on quantity rather than the quality of those Resources. In the process of scoring the programs, there would obviously need to be a discussion regarding the needed skill set and if it exists within the organization, but it ultimately becomes a simple Yes/No answer when all parties involved agree on the skill set itself.

3.2.4 Business Capabilities

Of the four factors contributing to program success, Business Capabilities is the most difficult to assess and, therefore, the most difficult to provide a satisfactory method to assign a score. As defined earlier, Business Capabilities "are complex bundles of skills and accumulated knowledge, exercised through organizational processes that enable firms to coordinate activities and make use of their assets" (Day, 1994).

The identification and analysis of Business Capabilities has become a source of research and commercial opportunities in itself. Many consulting firms have developed their own, proprietary methodology for identifying the maturity of an organization's Business Capabilities. Deloitte, Gartner and Accenture are three of which that have similar methodologies. What is important for this research is the use of some methods to provide a maturity score as a basis for providing a score for the Business Capabilities factor.

Deloitte has developed their own methodology based on their own and others' research as well as the large amount of data obtained by performing such assessments. More details on their methodology are provided below, but it is important to mention that the proposed scoring model is not entirely dependent on using Deloitte's method. As shown in Table 1 above, the percentage assigned in the proposed scoring model relates to the score given through Deloitte's capability maturity assessment.

The proposed scoring model translates Deloitte's scores into a corresponding percentage to use in the calculations. There is not any reason why another consulting firm's business capability scoring method, or organization's internal business capability scoring method, could not be translated to fit into the proposed model following the same rough guidelines (splitting the scores into corresponding ranges of 10 percentage points). It is only a question of the accuracy of the business capability scoring that limits its usefulness. If the business capability assessment does not accurately reflect the actual state of an organization's Business Capabilities, the proposed scoring model will be flawed to the same extent.

Deloitte's business capability assessment model being used in this research is not to be considered an endorsement or preference for use of their model. It was used in this research because the subject company had already conducted the assessment and had the data available. Based on the wide usage of Deloitte's model, it does suggest a certain level of confidence in the findings of the assessment by business leaders. If the subject company had completed the same assessment using another company's methodology such as Gartner, the proposed scoring model would have used Gartner's business capability maturity scores as the basis for the Business Capability factor in this research.

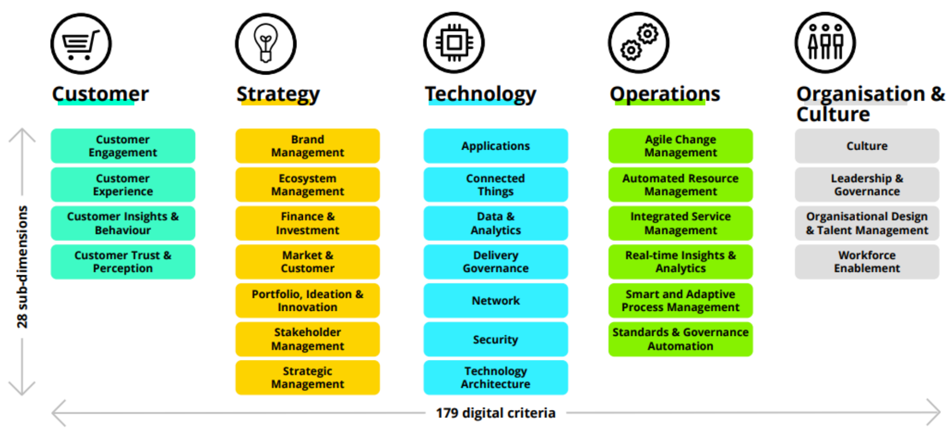
It may be suggested that, for the purpose of this research, a business capability maturity assessment methodology be developed for use with the proposed scoring model. This could then be used in place of or to compare to the results using Deloitte's methodology. In order to carry out such an assessment, it would be necessary to spend at least as much time analyzing the organization's business capability maturity as to complete the current research project. The subject organization spent in the range of $500,000 and nearly six months going through Deloitte's analysis with a team of consultants. For this current research, creating another business capability maturity assessment methodology is not feasible but is a point of possible future research and will be discussed in chapter 5.

3.2.4.1 Deloitte's Capability Maturity Assessment Methodology

Due to the fact that Deloitte's Assessment is proprietary and a product/service they sell to organizations, many of the details are not available outside of Deloitte. For our purposes, however, all the details are not necessary in order to fit it into the research being done regarding the proposed scoring model.

In assessing an organization's capabilities, Deloitte uses the term "maturity" to quantify the capabilities. The higher the score, the more "mature" (established, used and understood within the organization) the capability. These capabilities are broken into five core dimensions of Customer, Strategy, Technology, Operations and Organization & Culture. These are, in turn, divided into sub-dimensions that are further broken out into individual criterion (see Figure 3.1 below).

Figure 3.1 – Deloitte Overview of the Core Dimensions and Sub-Dimensions



The beginning of the assessment consists of sending out a survey to key people across all functions of the organization. These are used to assess the current "maturity" across the various criteria. Below in Table 3.2 is an example of the type of questionnaire used for capability assessment.

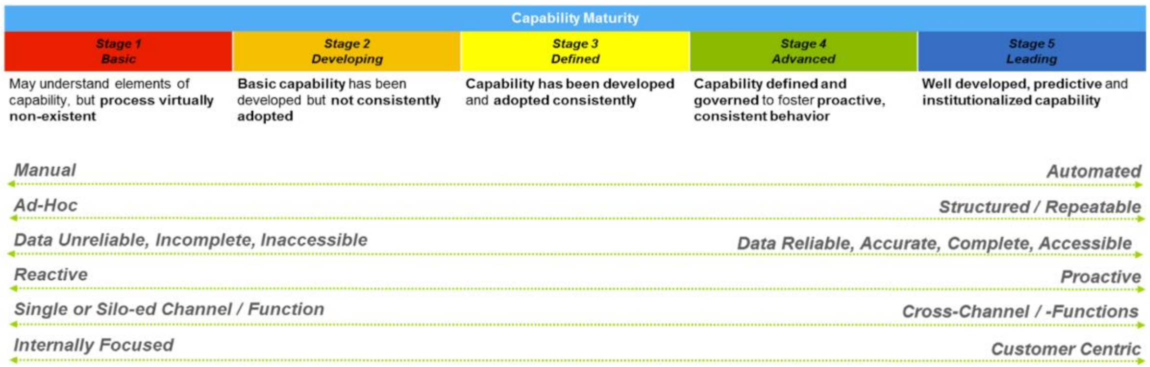
Table 3.2 - Example Assessment Questionnaire

#	Questions	Answers
1	Name	
2	Role / Title	
3	For which business process are you completing this survey?	
4	How many years have you been at [Company]?	
5	What elements are most important to incorporate into the business process maturity for [Company]?	
6	What will success look like at the end of the business process maturity?	
7	Growing profitably and leveraging [Company's] competitive advantages is a critical element of success. Is your business process currently achieving this business strategy?	
8	What has been the greatest pain point in executing your business process as [Company] has grown and scaled operations?	
9	Is there any other relevant information you would like to add relating to the maturity of your business process?	

Deloitte then conducts interviews with the respondents to clarify and gain further illumination in order to obtain a deeper understanding of the responses. Following this, Deloitte conducts "Labs" or meetings with groups of individuals to deepen the understanding of the organization.

From these questionnaires and "Labs", Deloitte is able to provide an initial score for the individual criteria of a number between 1 and 5 indicating the "maturity". Below is a graphical representation of what the numbers indicate in terms of real business action in Figure 3.2.

Figure 3.2 - Deloitte Maturity Scoring Explanation



Once these scores are obtained, Deloitte normalizes these against organizations that are similar in industry, size, structure, etc. to account for any biases that may be present through the questionnaire and "Labs".

What is presented is a score of the various capabilities within the organization (or not existing within the organization) as well as how those compare to other organizations similarly situated. Advice and other information are offered on areas to improve, how strengths may be leveraged in different ways, and other aspects that do not pertain to this research. The important aspect of this process as it relates to the proposed scoring model, is a listing of Business Capabilities and the level of "maturity" for each.

3.2.4.2 Identification of Capability & Translating Deloitte's Maturity Score

The long list of Business Capabilities and associated scores then become a governing document within the Program Management Office (PMO) as a guide for what needs to be enhanced in the organization. Relating this back to the proposed scoring model must go through one more process in order to be of use in the proposed scoring model. It is necessary to identify what capability or capabilities would be enhanced by any given program.

This must be done in the conference room with key stakeholders, such as Enterprise Architects, to properly identify where it fits into the capabilities listed and how much the capability scores will change. Once identified, the change in capability score from Deloitte is used to determine the percentage used in the proposed scoring model for the Final Score calculation.

If only one capability is identified within the program, then the calculation is straightforward. However, if a program contributes to multiple Business Capabilities it would not simply be enough to average the capability scores to arrive at the proper percentage to use. It may be the case that a program greatly contributes to one capability but only contributes very little to another (or more). It is then necessary to weight the averaging of the capability scores based on how much is contributed to each capability to account for this.

3.2.5 Weighting of the Four Factors

The actual scores for the proposed scoring model are a function of the assigned percentage multiplied times the weight of the individual factor. The weights, as shown in Table 3.1, for Business Capabilities, Resources, Program Dependencies, and Business Value are 40, 24, 20 and 40, respectively. The weights, as can be quickly determined, add up to more than 100. The total weight adding to 124 is due to how the Business Value factor is scored. The highest possible percentage (for Revenue Efficiency) is 40% giving the highest maximum score for the Business Value factor of 16. With all other factors at 100%, this produces a highest possible Total Final Score of 100.

There are three reasons for the weighting of Business Capabilities and Business Value to be far greater than the two others. First, the proposed scoring model is intended to place an emphasis on greater ROI for IT programs. Alignment with an organization's strategies is a way of ensuring that greater ROI. The business strategies, as they relate to IT, should align with both increasing Revenue Efficiency and having a high Compliance Impact. Operational Efficiency and Legal Impact are simply maintaining functions of IT as a provider of technology to an organization but are, nonetheless, important in their own right.

Secondly, IT programs that move towards improving the Business Capabilities help ensure successful programs beyond just coming in on time and under budget. This forces decision makers to make IT program decisions that are relevant within the organization as a whole.

Lastly, based on the review of the relevant literature, lack of "connectedness" to the organization results in IT programs being considered as irrelevant and are thus a low priority for the stakeholders outside the IT department. When the argument can be made that a program is providing some real benefit to the stakeholders, they are more likely to engage in the program.

Resources are an especially fixable issue. If a program offers a high ROI potential, Compliance Impact, and greatly improves the organization's Business Capabilities, then that program would be a good candidate to proceed with. It may be the case that the necessary Resources may not be available. In such a case, finding the right amount of people with the right skill set becomes simply a budgetary issue. Investing in such a program could be worth the capital spent upfront.

Program Dependencies are one aspect of program management that simply cannot be avoided. While the risk must be accounted for, it can only be eliminated in an organization that has only one project for one purpose in process or in the planning stages. Such an organization would be simply too small or too stagnant to be wrestling with the issues discussed in this research.

3.2.6 Other Considerations

Whenever scoring is involved, whether it be in IT program selection or in sports, the possibility of a tie score must be considered. The “Golden Goal” method of deciding between seemingly equal programs is one way in which to make a choice, when the choice must be made. This would be having one aspect be the deciding factor. For instance, an organization may decide that its ultimate priority for IT programs be the cost, so the program with the lower budget impact would win out. The same could be done using the benefiting department, location, product line or business capability.

This can be valid but is still more arbitrary than what is being attempted with the proposed scoring model. Therefore, the proposed model will follow the same reasoning as in the previous sections and maintain its emphasis on Business Capabilities as a key driver. First, it is highly unlikely given the scoring model’s method of scoring Business Value that two programs falling in two different Business Value categories would end up with the same score, thus eliminating the need for that as a consideration. Secondly, previous sections demonstrate the importance of Business Capabilities to the ROI perspective and aligning with organizational strategy. From this, we can derive the following rule to follow when a choice must be made between two programs. If two programs have equal Total Final Scores and a choice must be made to implement or continue only one of them, the program that improves the greatest number of business capabilities will be chosen.

3.3 Scoring Model Validation Process

The proposed scoring model, in order to test for its ability to predict program success, underwent two phases of testing. The first phase, or Historical Phase, consists of applying the model to historical program data to determine if it is able to predict whether or not those programs were successful. There are obvious limitations to how the scoring model could be applied to the historical programs, such as a lack of input from stakeholders on business capability applicability, which will be discussed in later sections. However, this phase of testing should provide an adequate amount of data to draw some conclusions.

The second phase, or Experimental Phase, consists of implementing the scoring model for use within the same organization that the historical program data was obtained. This implementation of the scoring model is to say the model was used by the decision makers, with the other stakeholders' input collected, to make decisions on selecting, rejecting or continuing programs. The data on the performance from the Experimental phase is also analyzed to determine if the scoring model accurately predicted success for the programs. The rate of accuracy is also compared to that of the Historical Phase to determine if full implementation had a significant effect on the scoring model's ability to predict success.

3.4 Data & Analysis Tools

The data used for this research was obtained from a mid-sized, Software as a Service (SaaS) corporation which provides IT and Security monitoring tools as its primary products. The data source, referred to as the IT Program Funnel, contains program data for use in the Historical Phase from May 1, 2017 to January 31, 2019. The

IT Program Funnel also contains program data for use in the Experimental Phase dating from February 1, 2019 to June 30, 2019.

The IT Program Funnel data includes: programs numbers, IT department names, IT teams, project start/end dates, criteria and their weights (Run/Grow/Transform, Executive Recommendation, and In Flight projects), Program Dependencies, Business Capability name, Business Capability score, Business Capability range score, Business Value, Resources, total score (legacy criteria) , total score (new model), selected legacy programs, selected programs based on the new model and return on investment (ROI).

As part of the agreement to use the data for this research, the programs names, resource names, any reference to company information and program dependency names have all been masked.

The criteria of Run/Grow/Transform, Executive Recommendation, and In Flight programs were used as selection criteria for the programs within the legacy decision making model from February 1, 2018 to January 31, 2019. The proposed scoring model was used alongside the legacy criteria from February 1, 2019 to June 30, 2019.

The tool used to analyze the data from both the Historical Phase and Experimental Phase was the open source RStudio Statistical Tool. It was chosen to perform the analysis using statistical methods and algorithms to test the hypotheses in section 1.6.

3.5 Data Analysis

Several analysis methods were used to validate the response variables using the predictor variables. Table 3.3 below illustrates the variables and analysis methods used for each hypothesis.

Table 3.3 - Data Analysis Table

Hypothesis	Response Variable (Y)	Predictor Variables (X)	Analysis Method
H1: Business Capabilities, Resources, Program Dependencies, and Business Value can be used to forecast success of IT programs.	Success (Legacy)	Legacy: Run/Grow/Transform, Executive Recommendation, In Flight projects	Backward elimination process Forward elimination process Stepwise elimination process Binomial logistic regression Random Forest
	Success (New)	New proposed criteria: Business Capabilities, Resources, Program Dependencies, and Business Value	Backward elimination process Forward elimination process Stepwise elimination process Binomial logistic regression Random Forest
	Success (Legacy/ New)	New + Legacy: Business Capabilities, Resources, Program Dependencies, Business Value, Run/Grow/Transform, Executive Recommendation, In Flight projects	Backward elimination process Forward elimination process Stepwise elimination process Binomial logistic regression Random Forest
H2: A score based on Business Capabilities, Resources, Program Dependencies, and Business Value can predict success of IT programs.	Success (Legacy)	Legacy: Run/Grow/Transform, Executive Recommendation, In Flight projects	Random Forest
	Success (New)	New proposed criteria: Business Capabilities, Resources, Program Dependencies, and Business Value	Random Forest
	Success (Legacy /New)	New + Legacy: Business Capabilities, Resources, Program Dependencies, Business Value, Run/Grow/Transform, Executive Recommendation, In Flight projects	Random Forest

For H1, the Response Variable was the Success Status (Yes/No status of whether or not a program was successful) for both the Legacy decision making model and the proposed scoring model. The predictor variables were different for the legacy decision making model and the proposed scoring model. Different in that they measured or identified different aspects of the programs within the data. However, they are both factors used within the respective models that the decision (Success Status) is based upon. For the legacy decision making model, the predictor variables were Run/Grow/Transform, Executive Recommendation, and In Flight programs. For the proposed scoring model, the predictor variables were Business Capabilities, Resources, Program Dependencies, and Business Value. Two hybrid models were used in the analysis where all predictor variables from both the legacy decision making model and the proposed scoring model are included. One of these hybrid models uses the legacy decision-making model's Selected Success Status as the response variable and the second model uses the proposed scoring model's Success Status as the response variable.

H1 was tested using various Binomial Regression methods. These were chosen as they are useful in identifying, eliminating and weighting the statistical significance of predictor variables. The Binomial Logistic Regression is used to determine the significance of the individual predictor variables. Backward Elimination was used to eliminate those variables that do not have any statistical significance, testing that the four factors are in fact significant. Forward Elimination was used to identify those variables with the most improvement to the tested models and thus testing the validity of their inclusion and weighting within the scoring models structures. As the Forward and Backward Elimination were not used to create the proposed scoring model, but rather to provide evidence in support of H1, Stepwise Elimination was also used in order to further test the model as a whole and provide more insight into H1.

Random Forest method was then used to validate the importance of the four factors as predictor variables within the proposed scoring model. It also was used to determine the accuracy of the proposed scoring model. In terms of the legacy decision making model, it was used to validate the corresponding predictor variables of Run/Grow/Transform, Executive Recommendation, and In Flight projects. Its use on the Legacy decision making model would also provide a level of accuracy for comparison.

In the testing of H2, we have a Response Variable of Success for both the legacy model and proposed model along. The same predictor variables in H1 are used in the testing of H2. This analysis consisted of using Random Forest methodology to determine the accuracy rate of success based on proposed and legacy predictor variables. Random Forest was also used with the two hybrid models using all predictor variables with the Legacy Response Variable for one hybrid model and the Proposed Response Variable for the other hybrid model.

The P value is used to test the validity of the accuracy rates of predicting success within the Random Forests analysis. The null hypothesis is the models tested using proposed criteria are not able to predict the success of the programs. If the P value is less than 0.05, there is strong evidence to reject the null hypothesis, thus the model can predict success at the given accuracy rate. If the P Value is greater than 0.05, there is not enough evidence to reject the null hypothesis and the model cannot predict success at an accuracy rate greater than a model using other predictor criteria (Wasserstein and Lazar, 2016).

Chapter 4—Results

4.1 Introduction

The data for this research consists of the IT Program Funnel as previously discussed in section 3.4. The IT Program Funnel includes program data spanning from May 1, 2017 through June 30, 2019. This data is broken into two sets of data: Historical Data and Experimental Data. Historical Data contains the program data from May 1, 2017 to January 31, 2019 when the legacy decision-making model (Legacy Model) was used to make program decisions. Experimental data contains program data from February 1, 2019 to June 30, 2019 when the proposed decision-making model (Proposed Model) was implemented for use in the IT PMO decision-making process.

The following section, 4.2, discusses in detail the analysis methods used to test both hypotheses, introduced previously in section 1.6. Following the discussion of the analysis methods, section 4.3 discusses the details regarding the Historical Data as well as the results from the analysis and how those results relate to both hypotheses. Section 4.4 proceeds to discuss the Experimental Data and the results of that analysis in relation to the hypotheses.

4.2 Analysis Method

Combination of Binomial Logistic Regression and Random Forest are used to test the hypotheses for the Historical Data and Experimental Data. It is important to note that the Legacy Model was used to make program decisions within the Historical Data set and the Proposed Model was used to make program decisions within the Experimental Data set. Each data set will be used to provide a comparison of the Legacy Model, the Proposed Model and three hybrids models.

The first of the three hybrid models use all the criteria in both the Legacy Model and the Proposed Model, but the selection is made based only on the Legacy Model criteria. This hybrid model will be referred to as the Legacy Model Selection -All Criteria. The purpose of using this model is to test the significance of all the criteria across the Legacy and Proposed Models. Based on the P-Value in a Binomial Logistic Regression, the data will show if any of the criteria outside those used for the Legacy Model are more significant.

The second hybrid model works the same as the Legacy Model Selection -All Criteria except it is the Proposed Model's criteria that are used to make the program selections. This hybrid model will be referred to as the Proposed Model Selection – All Criteria.

The third hybrid, which will be referred to as the Proposed Model Selection + Legacy, includes the criteria from the Proposed Model plus the significant criteria from the Legacy Model. For the analysis of the Historical Data, the significant Legacy criteria is R.G.T. and the significant criteria for the Experimental Data is Executive Recommendation. The reason for and significance of this model will be discussed in Chapter 5.

4.3 Analysis of Historical Data

The Historical Data are from a mid-sized, Software as a Service (SaaS) corporation which provides IT and Security monitoring tools as its primary product. The Historical Data includes programs planned between the dates of May 1, 2017 to January 31, 2019. During this time there were a total of 284 programs.

Table 4.3.1 below shows the first 16 programs from the Historical Data and the Legacy Model criteria along with selections based on that model. The first column is the program number used in place of the program name as the agreement with company to use this data included an agreement to mask all names. The second and third columns are the IT department and team, respectively, involved with the program. The program planned start and end dates are in the following columns.

The Legacy criteria of R.G.T (Run, Grow and Transform) with an associated score of 0.5, 0.3 and 0.2 in the next column. This criterion is intended to categorize the IT Programs into three segments. Run or “R” is intended to signify operational programs intended to maintain IT systems and infrastructure. Grow or “G” is meant for programs aimed at expanding the existing processes. Transform or “T” signifies adding new processes and/or capabilities.

The next two criteria are Executive Recommendation and In-flight. Executive Recommendation is a binary criterion (1 meaning yes and 0 meaning no). It is simply an indicator of whether or not the program is based on a decision made by an executive or is not. In-Flight is an indicator of whether or not a program has already begun and is in process at the time of the report. Legacy Program Selection is whether or not the Legacy Model, based on its criteria, would select the program.

Table 4.3.1 – Sample of Historical Program Data (Legacy Model)

Program #s	IT Departments	IT Teams	Planned Start Date	Planned End Date	Run Grow Transform	R/G/T Value	Executive Rec. (Y [1]/N[0])	In-Flight (Y [1]/N[0])	Total Priority Score-Legacy score	Legacy Program Selection
1	Business Applications	App Integration	5/1/2018	9/1/2018	T	0.2	1	0	17	Yes
2	Business Applications	App Integration	10/1/2018	1/31/2019	R	0.5	0	0	0	Yes
3	Business Applications	App Integration	5/15/2018	7/15/2018	G	0.3	1	0	17	Yes
4	Business Applications	App Integration	5/1/2018	8/31/2018	G	0.3	1	0	17	Yes
5	Business Applications	App Integration	2/12/2018	4/30/2018	R	0.5	1	0	17	Yes
6	Business Applications	App Integration	11/1/2018	12/15/2018	R	0.5	1	0	17	No
7	Business Applications	App Integration	11/1/2018	1/31/2019	R	0.5	0	0	0	No
8	Business Applications	App Integration	10/15/2018	1/31/2019	R	0.5	1	0	17	No
9	Business Applications	App Integration	11/1/2018	1/31/2019	R	0.5	1	0	17	No
10	Business Applications	App Integration	2/1/2018	4/30/2018	G	0.3	1	0	17	No
11	Business Applications	App Integration	11/1/2017	1/31/2018	R	0.5	1	0	17	No
12	Business Applications	App Integration	11/1/2017	1/31/2018	R	0.5	0	0	0	No
13	Business Applications	App Integration	12/1/2017	2/15/2018	R	0.5	1	0	17	Yes
14	Business Applications	App Integration	9/1/2017	2/16/2018	R	0.5	1	0	17	Yes
15	Business Applications	App Integration	2/1/2018	4/30/2018	R	0.5	1	0	17	Yes
16	Business Applications	App Integration	2/1/2018	4/30/2018	R	0.5	1	0	17	Yes

Table 4.3.2 shows the Proposed Model as it is applied to the sample of Historical Data. The Proposed Model includes Business Capabilities, Resources, Program Dependencies, and Business Value with weights at 40, 24, 20 and 40, respectively. These weights are used to calculate the total score and ultimately aiding in making the selection of the programs. Business Capabilities scores are determined based on the difference of the capability score from the starting point of the program to the score where capabilities will be after the program is completed. Business Values are determined based on strategic direction of the organization including legal and compliance, Resources based on available skill sets to finish the program and Program Dependencies is determined by the programs being dependent to each other.

Table 4.3.2 – Sample of Historical Program Data (Proposed Model)

Program #s	IT Departments	IT Teams	Planned Start Date	Planned End Date	Bus Capability Name	Bus Capabilities	Bus Capabilities Range	Bus Value score	Resources (skill set) (Y/N)	Program dependencies(Y/N)	Total New score	New score selection
1	Business Applications	App Integration	5/1/2018	9/1/2018	Enterprise Data Management	0.1	0.1-0.5	0.4	Y	Y	64	Yes
2	Business Applications	App Integration	10/1/2018	1/31/2019	Employee Benefits	0	0.0-0.0	0.3	Y	N	36	No
3	Business Applications	App Integration	5/15/2018	7/15/2018	Software Service Fulfillment	0	0.0-0.0	0.4	Y	N	40	Yes
4	Business Applications	App Integration	5/1/2018	8/31/2018	Finance Planning & Analysis	0.1	0.1-0.5	0.2	Y	N	36	No
5	Business Applications	App Integration	2/12/2018	4/30/2018	Workforce Planning	0	0.0-0.0	0.2	Y	N	32	Yes
6	Business Applications	App Integration	11/1/2018	12/15/2018	Business Intelligence	0	0.0-0.0	0.3	Y	N	36	No
7	Business Applications	App Integration	11/1/2018	1/31/2019	Employee Benefits	0.1	0.1-0.5	0.3	Y	Y	60	Yes
8	Business Applications	App Integration	10/15/2018	1/31/2019	Information Architecture	0.1	0.1-0.5	0.2	N	N	12	No
9	Business Applications	App Integration	11/1/2018	1/31/2019	Revenue Recognition	0	0.0-0.0	0.4	Y	N	40	Yes
10	Business Applications	App Integration	2/1/2018	4/30/2018	Customer Success	0	0.0-0.0	0.4	Y	Y	60	Yes
11	Business Applications	App Integration	11/1/2017	1/31/2018	Data Integration	0	0.0-0.0	0.2	N	Y	28	No
12	Business Applications	App Integration	11/1/2017	1/31/2018	Customer Success	0	0.0-0.0	0.4	N	N	16	No
13	Business Applications	App Integration	12/1/2017	2/15/2018	Information Technology	0.1	0.1-0.5	0.2	N	N	12	No

4.3.1 Hypothesis Testing Using Historical Data

***H1**: Business Capabilities, Resources, Program Dependencies, and Business Value can be used to forecast success of IT programs.*

H1 is to determine if the proposed model and its criteria are significant in the selection of programs that forecast higher success rate. Utilizing two statistical algorithms, Random Forest and Binomial Logistic Regression, the significance of the criteria and the accuracy of the model is determined. All five models are being tested in this section using the Historical Data set.

H1 - Random Forest

Random Forest model is a type of additive model that makes predictions by combining decisions from a sequence of base models. The equation is shown below:

$$g(x) = f0(x) + f1(x) + f2(x) + \ldots$$

where the final model g is the sum of simple base models f_i. In this section five total models have been tested and the results are shown in Table 4.3.3.

Table 4.3.3 - H1 Confusion Matrix and Statistics – Historical data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model -legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Accuracy	0.85	0.8511	0.5786	0.8511	0.8511
95% CI	(0.7799, 0.9047)	(0.7814, 0.9054)	(0.4923, 0.6615)	(0.7814, 0.9054)	(0.7814, 0.9054)
P-Value	4.278e-12	1.506e-12	0.5359	1.506e-12	1.506e-12
Kappa	0.6799	0.6852	0	0.6852	0.6852
Mcnemar's Test P-Value	0.0004803	0.00225	4.321e-14	0.00225	0.00225
Sensitivity	0.6780	0.7000	0	0.7000	0.7000

Based on the results shown above on table 4.3.3, The Proposed Model with proposed model criteria, Proposed Model + Legacy and Proposed Model – All Criteria are performing well with accuracy of 85.11% and p-value of 1.506e-12. Overall, the table indicated that the Proposed Model's criteria with any hybrid combination are performing well.

Table 4.3.3.1 - H1 Random Forest Results per Model– Historical data

	Proposed Model – All criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Accuracy	0.8511	0.8511	0.8511
95% CI	(0.7814, 0.9054)	(0.7814, 0.9054)	(0.7814, 0.9054)
P-Value	1.506e-12	1.506e-12	1.506e-12

H1 - Binomial Logistic Regression

The Binomial Logistic Regression is used to determine the significance of the individual criteria as well as predicting the relative success of the five models being analyzed.

The equation for Binomial Logistic Regression is shown below:

$$\pi i = Pr(Yi = 1|Xi = xi) = exp(\beta 0 + \beta 1xi)1 + exp(\beta 0 + \beta 1xi)$$

Where Variables are:

Let *Y* be a binary response variable -Success of Programs

Y_i = 1 when program is successful

Y_i = 0 When program is not successful

$X = (X_1, X_2, ..., X_k)$ be a set of explanatory proposed criteria. x_i is the observed value of the explanatory variables for observation *i*.

The results are shown in table 4.3.4 for all models.

Table 4.3.4 - P Value and AIC per Model - Historical Data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model -legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
R.G.T	0.0203	0.05494	0.00697	N/A	0.04049
In Flight	0.9863	0.53258	0.98470	N/A	N/A
Exec. Rec	0.8825	0.95102	0.60440	N/A	N/A
Business Value	0.5168	2.43e-05	N/A	1.27e-06	2.29e-05
Business Capabilities	0.8033	0.00446	N/A	0.00465	0.00493
Resources	<2e-16	3.32e-13	N/A	9.08e-14	2.95e-13
Program Dependencies	0.0192	4.96e-09	N/A	2.02e-10	1.97e-09
AIC	**226.6**	**172.91**	**356.8**	**171.77**	**169.32**

*N/A – The criterion was not part of the model

Based on Binomial Logistic Regression results in table 4.3.4, there are three models that performed better based on the AIC (Akaike's Information Criterion) of 169.32, 171.77 and 172.91 for the Proposed Model + Legacy , Proposed Model with proposed model criteria, and Proposed Model – All Criteria, respectively. The results in table 4.3.4.1 demonstrate the Proposed Model's criteria are statistically most significant which contributes to the performance of the models.

Table 4.3.4.1 - P Value Results per Model - Historical Data

	Proposed Model – All criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
R.G.T	0.05494	N/A	0.04049
Business Value	2.43e-05	1.27e-06	2.29e-05
Business Capabilities	0.00446	0.00465	0.00493
Resources	3.32e-13	9.08e-14	2.95e-13
Program Dependencies	4.96e-09	2.02e-10	1.97e-09
AIC	**172.91**	**171.77**	**169.32**

*N/A – The criterion was not part of the model

Table 4.3.5 - Stepwise Binomial Regression Selection per Model - Historical Data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Forward Selection	Resources, In Flight, R.G.T, Program Dependencies,	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T	R.G.T, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T
Backward Selection	R.G.T, In Flight, Resources, Program Dependencies	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T	R.G.T, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T
Forward selection +Backward	R.G.T, In Flight, Resources, Program Dependencies	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T	R.G.T, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Business Value, Business Capabilities, Resources, Program Dependencies, R.G.T

Based on Backward, Forward and Stepwise regression results shown in table 4.3.5, all models including the Legacy Model - All Criteria demonstrate that Business Value, Business Capabilities, Resources and Program Dependencies are ranked among the highest significant criteria by these regression analyses.

Table 4.3.6 - Prediction Accuracy by Model - Historical Data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Pred Rate	Train: 35.61194 Test: 44.56	Train 59.47761 Test: 70.40667	Train: 0.3358209 Test: 0.4133333	Train: 63.46269 Test: 75.38	Train: 59.47761 Test: 70.40667

In table 4.3.6, the prediction accuracy shows that–Proposed Model with proposed model criteria has an accuracy of 75.38%. The Proposed model and its criteria are re outperforming the models using the Legacy Model criteria for determining success rate by a significant margin.

***H2**: A score based on Business Capabilities, Resources, Program Dependencies, and Business Value can predict success of IT programs.*

H2 determines if the Proposed Model and its criteria can predict the success of the selected programs based on proposed criteria. Testing of H2 is conducted using the Random Forest algorithm to determine the accuracy rate of successful prediction. All five models are being tested in this section using Historical Data set.

H2 - Random Forest

Table 4.3.7 - Confusion Matrix and Statistics – Historical data

Success Rate/per Criteria	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model +Legacy
Accuracy	0.8764	0.8764	0.5843	0.8764	0.8764
95% CI	(0.7896, 0.9367)	(0.7896, 0.9367)	(0.4749, 0.6879)	(0.7896, 0.9367)	(0.7896, 0.9367)
P-Value	1.809e-09	1.809e-09	0.5452	1.809e-09	1.809e-09
Kappa	0.7384	0.7384	0	0.7384	0.7384
Mcnemar's Test P-Value	0.07044	0.07044	3.252e-09	0.07044	0.07044
Sensitivity	0.7568	0.7568	0	0.7568	0.7568

Based on the results shown in Table 4.3.7, all models except for the Legacy Model are performing the same in terms of predicting the success rate of already selected programs with high accuracy rate of 87.64% and P-value of 1.809e-09 less than 0.05. This indicates that the Proposed Model criteria are the reason for the models performing well.

4.4 Analysis of Experimental Data

The Experimental Data comes from a mid-sized, Software as a Service (SaaS) corporation which provides network monitoring tools as its primary product. The Empirical Data includes programs planned between the dates of February 1, 2019 to June 30, 2019. During this time there were a total of 160 programs.

In table 4.4.1 below are the first 16 programs with the Legacy Model criteria and selection. The details regarding the meaning of the values within the various criteria are discussed earlier in section 4.3.

Table 4.4.1 – Sample of Experimental Program Data (Legacy Model)

Program #s	IT Department	IT Teams	Planned Start Date	Planned End Date	Run/ Change/ Transform	R/G/T Value	Executive Rec. (Y [1]/N[0])	In-Flight (Y [1]/N[0])	Total Priority Score- Legacy score	Legacy Program Selection
1	IT Operations	A/V	5/1/2019	7/31/2019	Run	0.5	1	1	81	Yes
2	Business Applications	App Integration	5/1/2019	8/15/2019	Change	0.3	1	1	73.4	Yes
3	Business Applications	App Integration	3/11/2019	7/31/2019	Transform	0.2	1	1	69.6	Yes
4	Business Applications	App Integration	4/29/2019	3/30/2020	Change	0.3	0	1	56.4	No
5	Business Applications	App Integration	5/1/2019	7/31/2019	Run	0.5	0	1	64	No
6	Business Applications	App Integration	2/1/2019	4/26/2019	Transform	0.2	0	0	7.6	No
7	Business Applications	App Integration	5/1/2019	9/30/2019	Transform	0.2	1	1	69.6	Yes
8	Business Applications	App Integration	5/1/2019	8/15/2019	Change	0.3	1	1	73.4	Yes
9	IT Operations	Collaboration	2/1/2019	7/31/2019	Run	0.5	0	0	19	No
10	IT Operations	Collaboration	5/15/2019	8/30/2019	Transform	0.2	0	0	7.6	No
11	IT Operations	Collaboration	5/1/2019	10/31/2019	Run	0.5	0	0	19	No
12	IT Operations	Collaboration	5/1/2019	12/31/2019	Run	0.5	0	0	19	No
13	IT Operations	Collaboration	2/28/2019	4/30/2019	Run	0.5	0	0	19	No
14	IT Operations	Collaboration	3/1/2019	4/30/2019	Run	0.5	0	0	19	No
15	IT Operations	Collaboration	3/15/2019	5/31/2019	Transform	0.2	1	1	69.6	Yes
16	IT Operations	Collaboration	2/1/2019	4/30/2019	Run	0.5	0	0	19	No

Table 4.4.2 shows the Proposed Model as it is applied to the sample of Experimental Data. The Proposed Model includes Business Capabilities, Resources, Program Dependencies, and Business Value at 40, 24, 20 and 40, respectively. The details regarding the values of these criteria are discussed in section 4.3.

Table 4.4.2 – Sample of Experimental Program Data (Proposed Model)

Program #s	IT Department	IT Teams	Planned Start Date	Planned End Date	Bus Capability Name	Bus Capability Range	Bus Value	Resources	Program dependencies	Bus Capability	Total New Score	New score selected
1	IT Operations	A/V	5/1/2019	7/31/2019	Solution Delivery & Support	0	0.2	1	0	0	32	No
2	Business Applications	App Integration	5/1/2019	8/15/2019	Solution Delivery & Support	0	0.2	1	0	0	32	No
3	Business Applications	App Integration	3/11/2019	7/31/2019	Solution Delivery & Support	0	0.4	1	0	0	40	Yes
4	Business Applications	App Integration	4/29/2019	3/30/2020	Solution Delivery & Support	0	0.4	1	1	0	60	Yes
5	Business Applications	App Integration	5/1/2019	7/31/2019	Revenue Management	0	0.2	0	1	0	28	No
6	Business Applications	App Integration	2/1/2019	4/26/2019	Infrastructure Services & Operations	0	0.2	1	0	0	32	No
7	Business Applications	App Integration	5/1/2019	9/30/2019	Infrastructure Services & Operations	0	0.2	1	0	0	32	No
8	Business Applications	App Integration	5/1/2019	8/15/2019	Customer Support	0	0.2	1	0	0	32	No
9	IT Operations	Collaboration	1/28/2019	7/31/2019	Collaboration	0.1-0.5	0.4	0	1	0.1	40	Yes
10	IT Operations	Collaboration	5/15/2019	8/30/2019	Collaboration	0	0.2	1	0	0	32	No
11	IT Operations	Collaboration	5/1/2019	10/31/2019	Collaboration	0	0.2	1	0	0	32	No
12	IT Operations	Collaboration	5/1/2019	12/31/2019	Collaboration	0	0.2	1	0	0	32	No
13	IT Operations	Collaboration	2/28/2019	4/30/2019	Collaboration	0.1-0.5	0.2	0	0	0.1	12	No

4.4.1 Analysis of Experimental Project data for hypotheses that were proposed:

***H1**: Business Capabilities, Resources, Program Dependencies, and Business Value can be used to forecast success of IT programs.*

H1 is to determine if the proposed model and its criteria are significant in the selection of programs that forecast higher return on investments. Utilizing two statistical algorithms, Random Forest and Binomial Logistic Regression, the significance of the criteria and the accuracy of the model is determined. All five models are being tested in this section using the Experimental Data set.

H1 - Random Forest

Table 4.4.3 - H1 Confusion Matrix and Statistics – Experimental data

	Legacy Model -All criteria	Proposed Model– All criteria	Legacy Model -legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model +Legacy
Accuracy	0.9423	0.9808	0.8654	0.9808	0.9216
95% CI	(0.8405, 0.9879)	(0.8974, 0.9995)	(0.7421, 0.9441)	(0.8974, 0.9995)	(0.8112, 0.9782)
P-Value	2.96e-11	4.772e-13	1.468e-07	4.772e-13	2.904e-08
Kappa	0.8846	0.9614	0.7316	0.9614	0.8384
Mcnemar's Test P-Value	1	1	0.4497	1	0.6171
Sensitivity	0.9600	0.9643	0.9200	0.9643	0.9655

Based on table 4.4.3, with an accuracy rate of 98.08% and p-value of 4.772e-13, Proposed Model– All Criteria, and Proposed Model with proposed model criteria are the highest performing models to determine success of the selected IT programs.

Table 4.4.3.1 - H1 Random Forest Result– Experimental data

	Proposed Model with proposed model criteria	Proposed Model – All criteria
Accuracy	0.9808	0.9808
95% CI	(0.8974, 0.9995)	(0.8974, 0.9995)
P-Value	4.772e-13	4.772e-13

H1 - Binomial Logistic Regression

Table 4.4.4 - P Value and AIC per model - Experimental Data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model +Legacy
R.G.T	0.01637	0.101376	0.00848	N/A	N/A
In Flight	0.98966	0.349400	0.00191	N/A	N/A
Exec. Rec	0.00119	0.031796	0.99108	N/A	0.561179
Business Value	0.63678	0.000569	N/A	3.72e-05	0.000598
Business Capabilities	0.30734	0.000977	N/A	4.04e-05	0.013177
Resources	0.05269	9.99e-05	N/A	1.41e-06	0.989527
Program Dependencies	0.00568	1.09e-05	N/A	1.01e-06	0.990847
AIC	**71.103**	**54.39**	**77.207**	**59.328**	**76.81**

*N/A – The criterion was not part of the model

Based on the Binomial Logistic Regression results in table 4.4.4, there are two models that performed better based on the AIC of 59.328 and 54.39 are Proposed Model with proposed model criteria and Proposed Model– All Criteria, respectively.

These results demonstrate the Proposed Model's criteria are the largest factor in the performance of the models. The most significant criteria in the mentioned models are Business Value, Business Capabilities, Resources and Program Dependencies.

Table 4.4.4.1 - P Value Results per model - Experimental Data

	Proposed Model – All criteria	**Proposed Model with proposed model criteria**
Business Value	0.000569	3.72e-05
Business Capabilities	0.000977	4.04e-05
Resources	9.99e-05	1.41e-06
Program Dependencies	1.09e-05	1.01e-06
AIC	**54.39**	**59.328**

Table 4.4.5 - Stepwise Binomial Logistics Selection by Model - Experimental Data

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Forward Selection	Exec Rec, R.G.T, In Flight, Resources, Program Dependencies	R.G.T, Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies	R.G.T, Exec Rec, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies
Backward Selection	Exec Rec, R.G.T, In Flight, Resources, Program Dependencies	R.G.T, Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies	R.G.T, Exec Rec, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies
Forward selection +Backward	R.G.T, Exec Rec, In Flight, Resources, Program Dependencies	R.G.T, Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies	R.G.T, Exec Rec, In Flight	Business Value, Business Capabilities, Resources, Program Dependencies	Exec Rec, Business Value, Business Capabilities, Resources, Program Dependencies

Based on Backward, Forward and Stepwise regression results shown in table 4.4.5, the Proposed models with any combination of criteria shown in the table demonstrate that Business Value, Business Capabilities, Resources and Program Dependencies including Executive Recommendation from Legacy Model are ranked among the highest significant criteria by these regression analyses.

Table 4.4.6 - Prediction Accuracy per Model

	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Pred Rate	Train: 12.65278 Test: 15.6338	Train: 49.31944 Test: 49.26761	Train: 0.125 Test: 0.1267606	Train: 49.31944 Test: 52.26761	Train: 49.31944 Test: 49.26761

In table 4.4.6, the prediction accuracy shows that the Proposed Model with proposed model criteria has an accuracy rate of 52.27%. The Proposed Model with combination of its criteria are outperforming the models using the Legacy Model criteria by a significant margin.

***H2**: A score based on Business Capabilities, Resources, Program Dependencies, and Business Value can predict success of IT programs.*

H2 determines if the Proposed Model and its criteria can predict the success of the selected programs based on proposed criteria. Testing of H2 is conducted using the Random Forest algorithm to determine the accuracy rate of successful prediction. All five models are being tested in this section using Experimental Data set.

H2 - Random Forest

Table 4.4.7 - Confusion Matrix| Statistics Experimental data

Success Rate/per Criteria	Legacy Model -All criteria	Proposed Model – All criteria	Legacy Model - legacy criteria	Proposed Model with proposed model criteria	Proposed Model with proposed model + Legacy
Accuracy	0.9038	0.9615	0.9038	0.9615	0.9423
95% CI	(0.7897, 0.968)	(0.8679, 0.9953)	(0.7897, 0.968)	(0.8679, 0.9953)	(0.8405, 0.9879)
P-Value	6.424e-10	2.53e-08	6.424e-10	2.53e-08	2.521e-07
Kappa	0.8077	0.9189	0.8077	0.9189	0.877
Mcnemar's Test P-Value	0.07364	0.4795	0.07364	0.4795	1
Sensitivity	0.8077	0.9394	0.8077	0.9394	0.9394

Based on the results shown in Table 4.4.7, the highest performing models are Proposed Model with proposed model criteria and Proposed Model with all criteria with accuracy rate of 96.15% with P value of 2.53e-08 in predicting the success rate of the programs. This indicates that the Proposed Model criteria are the reason for the models performing well.

Chapter 5—Discussion and Conclusions

5.1 Research Results

Previous research, as found in the review of existing literature, centered on several aspects of the program decision-making process within IT department. However, few looked at the process holistically and concentrated on particular aspects such as alignment with corporate goals or strategies [(Kamogawa, 2010), (Urhahn and Spieth, 2014), (Bucher and Min, 2017)], Program Dependencies [(Cho and Shaw, 2013), (Killen, 2017)], Business Value (Smith and Sonnenblick, 2013), or Business Capabilities [(Day, 1994), (Wu and Chen, 2014), (Sussan and Johnson, 2003)], to name a few. Of those that did focus on complete decision-making processes, many employed the use of mathematical models to dictate the decisions (Ghapanchi, 2012). The research presented here centers on the problem of the lack of an objective decision-making model for the optimal selection of IT programs that leads to lower returns on investments.

The three research questions this research attempted to answer was what are, if any, the proper criteria to select successful programs including increasing ROI (RQ1-3). Through research of the relevant literature, H1 was proposed identifying Business Capabilities, Resources, Program Dependencies and Business Value as the criteria able to select programs and prioritize IT programs (RQ4).

H1 was tested with both historical and experimental data containing the details of 444programs (284 programs in the historical data and 160 programs in the experimental data). Based on results from sections 4.3 and 4.4 with Binomial Regressions and Random Forest testing, Business Value and Business Capabilities, Resources and

Program Dependencies are statistically significant in both the historical and experimental phases.

The proposed model and its corresponding criteria were tested against the Legacy Model that was already in place at the subject company and was used to make program selection in the historical data. Hybrid models were also tested that included the criteria from both the Legacy Model and the Proposed Model with one of the models' criteria selecting the program.

Of the four models initially tested using Binomial Logistic Regression, for the Proposed Model + Legacy , Proposed Model with proposed model criteria, and Proposed Model – All Criteria performed best with an AIC (Akaike's Information Criterion) of 169.32, 171.77 and 172.91respectively on historical data (see Table 4.3.4) and with experimental data showing Proposed Model – All Criteria and Proposed Model with proposed model criteria with an AIC of 54.39 and 59.328 respectively (see Table 4.4.4). These tests indicated that the Legacy Model criteria of R.G.T. was also significant within most of the models with range of P value of 0.00697 – 0.0404 in the historical data. Executive Recommendation was the significant criterion with a P value of 0.03179in experimental data.

Based on this finding, a third hybrid model was tested, referred to as Proposed Model Selection + Legacy, to determine if the inclusion of R.G.T. for the historical data and Executive Recommendation for the experimental data as additional criteria within the Proposed Model increased the accuracy and R.G.T.'s and Executive Recommendation's relative significance to the other criteria. The Proposed Model Selection + Legacy performed similarly to the Proposed Model with an AIC of 169.32on historical data but was less effective on experimental data with an AIC of 76.81. The lower AIC is always favorable as it shows a better-fitted model to predict with a few predictor variables.

The Forward, Backward and Stepwise Regression Selection was also run against all five models on both the historical and experimental data. These analyses were used to obtain a ranking of the relative significance of individual criteria within each model.

In the analyses using historical data, every model/selection-analysis that included the Proposed Model's criteria, Business Capabilities is found to be a significant criterion in predicting success of the programs. The second criterion that appears in all but two model/selection-analysis including the Proposed Model's criteria is Business Value. Business Value and Business Capabilities only failed to rank significance in the Legacy Model - All Criteria model analyzed using Backward Selection and Stepwise Selection. The Legacy Model ranked only R.G.T. and In Flight as significant when no Proposed Model criteria were present. R.G.T. ranks as significant in the models that contain the Legacy criteria as well as Proposed Model + Legacy.

The analysis of the experimental data provided slightly different results (see Table 4.4.5). Any model using the Proposed Model criteria as the selection criteria show Business Value, Business Capabilities, Resources and Program Dependencies as significant. Similar to the analysis using historical data, the Legacy Model - All Criteria model only shows the Proposed Model criteria of Resources and Program Dependencies as being significant. Another similarity in the historical data analysis is that R.G.T shows as significant in any model that it is present as well as Executive Recommendation also shows as significant in all model/selection-analysis where it is present as a criterion.

Further analysis is completed to test the prediction of all five models in selecting the best programs for success. In historical data (see Table 4.3.6), the Proposed Model - All Criteria, and Proposed Model + Legacy including R.G.T have an accuracy rate of 70.41% which is higher than Legacy Models at range of 0.4133-44.56% A similar analysis is performed with experimental data which has the Proposed Model - All Criteria and Proposed Model + Legacy at 49.27% while the Proposed Model is 52.27%. The Legacy Model - All Criteria went down to 15.63% while the Legacy Model was reduced to .0.1267%.

To further test H1, Random Forest was used to determine the accuracy of each model's criteria. For the historical data (see Table 4.3.3), the three models that use the Proposed Model's criteria as the selecting factors had accuracy rates of 85.11% which is significantly higher than that of the Legacy Model with a 57.86%. The Legacy Model – All Criteria was only slightly less accurate with rate of 85% (see Table 4.4.3).

Based on the given results, the Proposed Model and its criteria are performing higher than the Legacy Model in selecting the successful programs.

H2 was tested with the same historical and experimental data as H1 containing the details of 444 programs (284 programs in the historical data and 160 programs in the experimental data). Based on results from sections 4.3 and 4.4 with a Random Forest analysis, the Proposed Model criteria are more accurate at predicting success than the Legacy Model criteria.

The Confusion Matrix shown in table 4.3.7, based on the historical data, shows the four models with the Proposed Model criteria at an accuracy rate of 87.64% as compared to the Legacy Model, the only model without Proposed Model criteria, with an accuracy rate of 58.43%. This clearly shows that the Proposed Model criteria are the main factors in providing the highest accuracy rate in prediction the success of the selected programs. The results for the experimental data provide even more evidence of this.

The Proposed Model and Proposed Model - All Criteria had the highest accuracy rate of 96.15% while the Proposed Model + Legacy had a rate of 94.23%, the second highest. The two models that used the Legacy Model criteria as the selection criteria had an accuracy rate of 90.3%. This indicates that the presence of the Legacy Model criteria lessens the ability of the model to accurately predict success and the Legacy Model likely tended to choose more programs while the Proposed Model refined the selection to those more likely to succeed.

5.2 Conclusions

This research project has shown, through statistical analysis, that the proposed scoring decision-making model was effective at increasing return on investment for IT programs as well as predicting program success. Outside of this statistical analysis, the resulting return on investment realized in the subject company's IT programs after implementation (during the Experimental Phase) was notable.

Given the results of the analysis above surrounding H1, the criteria of Business Capabilities, Resources, Program Dependencies, and Business Value can be used to forecast success of IT programs. The above analysis surrounding H2 shows that a score based on Business Capabilities, Resources, Program Dependencies, and Business Value can predict success of IT programs.

Following from the confirmation of the two hypotheses, it follows that a scoring model for the optimal program selection based on Business Capabilities, Resources, Program Dependencies and Business Value will cause an increase success in return on IT program investments.

5.3 Contributions to Body of Knowledge

The research presented here first contributes a decision-making model that moves beyond simply predicting program success or failure. This proposed model integrates the return on investment perspective other researchers have promoted for IT departments. Its success at increasing the return on investment for the subject company's IT programs at least demonstrates the feasibility of the approach.

All the articles found in the course of this research validated program decision-making models through mathematical modeling. This research, however, validated the proposed decision-making model by implementing it in a real-world environment.

Further contribution is made by the form of the proposed decision-making model. A majority of those proposed in prior research concentrate on the use of mathematics by decision makers in order to make the program selections. One of the goals of this research was to provide a decision-making model that could be used by decision makers and IT PMO without experience or training beyond what is expected by the average employee.

5.4 Recommendations for Future Research

This research project has also opened other avenues of research directly related to the proposed decision-making model. One of these avenues of research is the applicability of the proposed model outside IT programs. For instance, would the same model and approach work as well within other departments such as product management and development? The criteria may need to be altered to fit within the purpose and goals of the department, but research could validate the underlying model design and approach.

This research was limited to a mid-sized, SaaS corporation as the subject company. Research would be necessary to determine if the IT programs for other industries and company size are similar enough to those from the subject company to still be applicable. Similarly, research would be necessary to determine if programs with considerably longer time spans than those present in the data can be accurately selected using the proposed decision-making model.

Another area of possible research was brought up during the development of this research surrounding Business Capabilities. It was suggested that, as one alternative in validating the proposed criteria, a Business Capability maturity assessment be developed to compare to the proposed decision-making model's results using Deloitte's assessment. While the assessment is far too expensive and time-consuming to have been done for the purpose of this research, comparing the proposed decision-making model's selections using various business capability maturity assessments could provide insight to both the proposed model and the business capability maturity assessments.

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