Perceived Benefits for Customer Service of ITIL IT Control Use

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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the qualification of any other degree or diploma of a University or other institution of higher learning, except where due acknowledgement is made in the acknowledgements.

.....

Signature

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Abstract

IT service management is becoming more and more important in the current business environment. Especially the IT Infrastructure Library (ITIL) is a widely adopted and accepted IT service management framework (Wagner 2006). Organizations that adopt one of the IT service management frameworks expect to achieve a large range of benefits through the use of the frameworks. The major benefits that are expected to be realised include reduced costs, IT services that are tailored to the business needs, a higher quality of IT services, and improved customer satisfaction (OGC 2007a). Despite the growing importance and acceptance of IT service management and ITIL, there is not much literature that is concerned with the benefits that can be realised when one of the relevant IT service management frameworks is in place. Only a few studies were published in conference proceedings (e.g. Hochstein et al. 2005, Potgieter et al. 2005, Cater-Steel et al. 2006). Even though these studies were able to confirm some of the claims made by the Office of Government Commerce (OGC), the publisher of the ITIL series, there are still a lot of claims that are not evaluated to date.

This thesis is taking a Monte-Carlo method based simulation approach to identify some of the benefits of the ITIL for customer service. To achieve this, an initial research model was developed that represents the four most likely benefits for customer service of the use of ITIL and their relationship with customer service and the generation of business value. Subsequently the different path ways for the relationships were explored and models for each of the possible paths were designed. These models include a mediated model, an unmediated model and a partially mediated model. After defining the estimates and constraints for the simulation, the simulation was executed using a MS Excel spreadsheet.

The simulation results presented a large amount of data for each of the models and their relationships. The models produced normal distributions and showed stability for changed input and throughput parameters. The analysis of the findings showed that the changes in estimates for each of the models and the associated results of the simulation followed a linear pattern. The linearity of the models combined with

the normal distribution of the results offers a lot of opportunities for the use of the developed models. A further enhancement through a test with real-life data could provide the basis for a tool to quantitatively predict the impact of an ITIL implementation on customer service and the creation of value for the business. In addition the four most likely contributors to improved customer service based on the use of ITIL have been identified from a literature review. The identified contribution towards improved customer service of these four beneficiary factors is supported by the results of the simulation. Therefore the results of this thesis provide the research community with a model that could provide the basis for further exploration of the beneficiary effects of ITIL on customer service.

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List of Abbreviations

CCTA	Central Computer and Telecommunications Agency
CEO	Chief Executive Officer
CM	Capability Maturity
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CMMO	Central Money Markets Office
COBIT	Control Objectives for Information and Related Technology
CSI	Continual Service Improvement
ERV	Expected Relationship Value
eSCM-SP	eSourcing Capability Model for Service Providers
eTOM	Telecom Operations Map
GB	Giga Byte
GH	Giga-Hertz
IBM	International Business Machines
ICFR	Internal Control over Financial Reporting
ICS	Institute of Customer Service
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IPD-CMM	Integrated Product Development Capability Maturity Model
ISACA	Information Systems Audit and Control Association
ISACF	Information Systems Audit and Control Foundation
ISO	International Standards Organisation
IT	Information Technology
ITGI	Information Technology Governance Institute
ITIL	Information Technology Infrastructure Library
itSMF	Information Technology Service Management Forum
M_o_R	Management of Risks
MS	Microsoft
OGC	Office of Government Commerce

PC	Personal Computer
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PRINCE2	Projects in Controlled Environments
RAND	Random
SECM	Systems Engineering Capability Model
SLA	Service Level Agreement
SOX	Sarbanes-Oxley-Act
SPICE	Software Process Improvement and Capability Determination
SW-CMM	Capability Maturity Model for Software
TQM	Total Quality Management

Chapter – 1 Introduction

1.0 BACKGROUND

This chapter will provide background information to this thesis and information to the motivations of the author that lead to the development of this thesis. In addition the structure of this thesis is outlined in more detail.

This section will focus on providing background information to the IT service management area in general and to the IT Infrastructure Library (ITIL) in particular. Therefore some of the most important publications are presented and the position of ITIL within the IT service management area is explained.

The information technology area is a fast changing area and a challenging environment for every organisation. New technologies and methodologies evolve in ever shorter periods of time. Today no large organization can exist without using a number of instruments that originated in the IT area. In fact, Information technology has become a major asset for a lot of companies around the world. But with the ever increasing costs of IT and the fast changing environment, organizations have to be prepared to react to these changes in a timely and effective way. There are a number of IT frameworks and methodologies that allow organizations to do just that. Besides ITIL, these frameworks and methodologies include COBIT, ValIT, and CMMI. In addition there are related standards like the ISO/IEC 20000 series and the ISO/IEC 27001. According to the Office of Government Commerce (OGC) and a number of researchers, ITIL is widely adopted all over the world and currently the de facto standard for IT service management (Sallé 2004, Hochstein et al. 2005a, Hochstein et al. 2005b, Šimková et al.2006; OGC 2007a), though there are regional differences.

The Information Technology Infrastructure Library (ITIL) was first developed by the UK's Central Computer and Telecommunications Agency (CCTA), now known as Office of Government Commerce (OGC) and is strongly supported by the itSMF (Information Technology Service Management Forum) (Wagner 2006). The itSMF is a global forum for IT professionals.

ITIL is a service management framework that provides of set of best practices. ITIL v3 defines service management as "a set of specialised organizational capabilities for providing value to customers in the form of

services" (OGC 2007c, p. 15) and services are defined as "a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks" (OGC 2007c, p. 16).

According to publications of other researchers and the publishers of the ITIL book series; there are a lot of potential benefits that can be realised by organizations that adopt the ITIL IT service management framework. These benefits include improved customer satisfaction, reduced costs, improved use of skills and experiences (OGC 2007a), as well as higher efficiency of IT services and higher client orientation (Hochstein et.al. 2005a). A full list of potential benefits will be provided in the literature review section.

Currently ITIL is available in the 3rd Version. There are five main books in this ITIL series. These books are called Service Strategy, Service Design, Service Transition, Service Operation, and Continuous Service Improvement. These books build the core literature in the ITIL version 3 book series. There are additional books to support those who are not familiar with the previous ITIL versions. The five core books are built around the ITIL service lifecycle (see figure1). All five books are very consistent in the way they are structured. These books provide guidance to convert innovative ideas and concepts into services for customers, to solve problems with effective and enduring solutions, to control costs and risks that can potentially destroy carefully created value, and to learn from successes and failures to manage new challenges and opportunities (OGC 2007c).

1.1 MOTIVATION

The author first came into contact with the IT governance and IT service management area in the "Contemporary Information Technology Issues in Business" class at the Auckland University of Technology. In addition to finding the topic very interesting from the start, the author also immediately recognised an area where further research might be desirable or even required. A review of the currently available published literature showed that there are just a few studies published to date, that are concerned with ITIL in general and the benefits that come with the use of ITIL in particular.

The author's main motivation was to learn more about IT service management and ITIL in order to acquire a certain level of expertise in an area that offers a broad range of career opportunities and that needs further research to prove its value.

A successful completion of this thesis could provide a lot of benefits for a number of groups and individuals. The research community can benefit from research in the IT service management area through the creation of additional knowledge. The business community can profit through provision of more background information regarding the expectations associated with an ITIL adoption and the potential beneficiary effects of ITIL on customer service and the business itself. The author finally will profit from this thesis in regard of his future career opportunities by including the IT service management area into his fields of knowledge. A review of current job descriptions shows an interestingly high mentioning of knowledge about ITIL as one of the desired knowledge areas of applicants.

The author really believes that the results of this thesis will expand the body of knowledge regarding the IT service management area. It is expected that a model will be developed and tested that illustrates a relationship between the potential benefits of the use of ITIL and improved customer service on the one side and a relationship between improved customer service and the creation of additional value to the business.

1.2 RESEARCH PROBLEM AND QUESTIONS

There is not much literature published in scientific journals about IT service management in general and ITIL in particular. In fact there are just two published articles to date that are concerned with ITIL. Therefore there is a huge gap in research that should be closed in the future, mainly but not only because IT service management can become a valuable asset to most organisations if they take the right approach.

The reviewed literature suggests a lot of potential benefits for public and private organizations that adopt ITIL or other IT service management frameworks. As mentioned in Section 1.0 there is not much scientific proof of any of these benefits by now. Most of the claims are made by the Office of

Government Commerce (OGC), which is the publisher of the ITIL book series, and the IT service management forum (itSMF).

The aim of this research project is therefore to test some of those claims against the results of a simulation approach. For this purpose a research model is developed that focuses on certain areas that will potentially benefit an organization through improved customer service. The factors that lead to improved customer service will be selected from the literature that is concerned with the potential benefits of the use of ITIL. Finally a relationship between these benefits and improved customer service with the result of higher value of IT service management operations to the organization will be developed and tested.

This thesis will focus on the identification of the perceived benefits for customer service of the use of the ITIL framework. The main research question is defined as:

Q1: What are the perceived benefits for customer service of the use of ITIL?

In addition there are a number of other research questions that are concerned with the relationships between the variables and constructs in the research model. The research model will be introduced in more detail in Chapter 3.

The initial research model used in this thesis uses six variables. The variables are called Service Reliability, Service Consistency, Service Effectiveness, Client Orientation, Customer Service, and Business Value. It is expected that the use of ITIL has a beneficiary effect on service reliability and consistency and improves the effectiveness of those services, and enables a higher client orientation within the IT departments and their provided services. These four factors will lead to an improved customer service. The final assumption is that the ITIL-enabled and improved customer service will provide value to the business.

To answer the research questions a research methodology was selected. The methodology uses a simulation approach based on the Monte Carlo method. The input to the simulation will be randomly generated numbers within certain constraints.

These input values will be put through the different path models that are derived from the initial research model in order to achieve the required results. These results will then be analysed and used to answer the main research question and the hypotheses.

1.3 STRUCTURE OF THE THESIS

This thesis follows a logical sequence to communicate the research. The formalities section offers an abstract of this thesis, an acknowledgment and a list of contents. In addition a list of tables and a list of figures as well as a listing of the abbreviations used in this thesis are presented.

Chapter 1, the Introduction chapter, offers background information to the area of interest for this thesis as well as an outline of the research problem and the research questions and an outline of the structure of this thesis. The motivation of the author to do research in the IT service management area is also mentioned.

In Chapter 2 an extensive literature review of contemporary scientific publications is presented. This literature review includes literature concerned with the different IT governance frameworks and related frameworks and methodologies. The related frameworks that were considered include COBIT, PRINCE2, PMBOK, ValIT, and the different forms of CMMs. An overview of ITIL and the current ITIL book series is presented, too. The final two sections in Chapter 2 are concerned with business value and customer service.

Chapter 3 is the research methodology chapter. It starts with an overview of simulation theory. In addition, it contains a review of similar studies to determine how other researchers have identified and defined their research methodologies. Other topics in that chapter are the research design and the research model. The research design section will explain the process that was used to define the methodology used in this thesis. The research model is based on six variables and a number of relationships between these variables. In addition there is a section about the data requirements of this thesis. The data requirements include a definition of the estimates and constraints implemented in the Monte Carlo simulation method that is used in this thesis and an outline of how sensitivity analysis will be implemented. Finally the limitations of the simulation approach are mentioned.

Chapter 4 reports the findings of this research project. Therefore the distributions of the models for each setting of estimates are presented in order to perform sensitivity analysis on the results of the simulation. In addition a more extensive presentation of the results for the simulations that used the estimates that were derived from literature is presented. The influence of the number of repetitions on the results of the simulation are also identified and reported for three different numbers of runs.

Chapter 5 presents a discussion of the findings of this research. The discussion chapter presents a comparison of the results of this thesis and the results of other research done in this area. Some of the most interesting observations regarding the results of the simulation are presented. In addition the main research question and the five hypotheses are discussed and tested against the findings of the simulation and the conclusions are presented.

In Chapter 6 the final conclusions of this thesis are presented. In addition one section to the limitations of this thesis is presented. The limitations include general limitations of this thesis as well as specific limitations of the selected methodology. The last section in Chapter 6 is concerned with recommendations for further research.

The appendix contains the source code of the macro that was implemented in MS Excel in order to perform the simulation with a large number of repetitions and store the results of each simulation run. In addition the full results of the distributions for the three different models with the estimates set on the value derived from literature are presented. The number of distributions that are presented in the appendices is limited to three in order to present the full simulation results for the most likely case in each of the three models. A presentation of all distribution would have needed too much space within generating additional value.

This chapter contained an introduction to the area in which this thesis will be situated. In addition the research problem and the research methodology were presented and the author’s motivations to undertake this thesis were mentioned. The next Chapter will present a literature review of the contemporary literature regarding ITIL, IT service management, and related frameworks.

In addition literature will be presented that is concerned with the effects of IT service management on customer service and the effect of improved customer service on the creation of additional business value.

Chapter – 2 Literature Review

2.0 INTRODUCTION

This chapter provides a review of the contemporary literature about ITIL and the related frameworks. There is also a group of literature that identifies the business value of IT service management in general and ITIL in particular. The purpose of the literature review is to identify the context of study, problem areas, and the gaps in literature and potential questions for research. The aim is to provide sufficient detailed information about the topic area that ITIL is defined both within its literature and in relation to other control frameworks. There is an overview of related frameworks, methodologies, and standards, including COBIT, Val IT, PRINCE2, PMBOK, and the CMMs. In the field of the Capability Maturity Models (CMMs) a detailed discussion is made of CMM, CMMI, SPICE, and COBIT 4.1. Finally the areas of customer service are discussed, with the focus on the ISO/IEC 20000 series, and the business value of service management.

The chapter is structured into two main divisions. One to review and define ITIL and the other to review and define related frameworks. Two shorter sections follow that review customer perspectives and potential business value generation by the implementation of ITIL.

2.1 ITIL

The Information Technology Infrastructure Library (ITIL) was developed by the UK's Central Computer and Telecommunications Agency (CCTA), now known as Office of Government Commerce (OGC) and is strongly supported by the itSMF (Information Technology Service Management Forum) (Wagner 2006). The itSMF is a global forum for IT executives.

ITIL is a service management framework that provides of set of best practices. ITIL v3 defines service management as "a set of specialised organizational capabilities for providing value to customers in the form of services" (OGC 2007c, p. 15) and services are defined as "a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks" (OGC 2007c, p. 16).

The goal of ITIL is the direction of IT services to current and future requirements of the business and its customers, to improve quality of service, and to reduce long-term cost of service activity (Wagner 2006). ITIL is an IT service management framework that provides a broad range of different best-practices to deal with the different IT processes (Schlarman 2007). It provides companies with information about how it should be done rather than what should be done. To identify what has to be done to achieve IT excellence companies should rather implement COBIT (Control Objectives for Information and Related Technology) (Robinson 2005; ITGI 2007).

According to the OGC and a number of researchers, ITIL is widely adopted all over the world and the de facto standard for IT service management (Sallé 2004, Hochstein et al. 2005a, Šimková et al. 2006; OGC 2007a), though there are regional differences. ITIL has its highest adoption rate by private and public organisations in Australia and Europe (Wagner 2006). A selection of well known high-profile organizations that included ITIL in their IT service management strategies includes IBM, Procter and Gamble, Shell, and Boeing (Sallé, 2004).

A sign for the growing importance of ITIL is the adoption of the ISO/IEC 20000 standard by the member countries of the ISO standards, because this new standard is mainly based on the BS 15000 (itSMF 2007), which is in return a strong supporter of the ITIL best practice processes and was initially designed in alignment with the ITIL development.

Although ITIL becomes increasingly important to practitioners, there are just a few publications about ITIL in relevant scientific sources (e.g. Hochstein et al. 2005b; Potgieter et al. 2005; Cater-Steel et al. 2006). This clearly shows that there is still a lot of research to be done to build more scientifically relevant knowledge about ITIL and IT service management in general.

A major advantage of an ITIL adoption is the fact that ITIL enables the IT departments to react faster to changed business needs (Murray et al. 2007). Another advantage, identified in a different study, is the fact that “customer satisfaction and operational performance improve as the activities in the ITIL framework increases“ (Potgieter et al. 2005, p. 166). Hochstein et al. (2005b) found that reference models, like ITIL, are a helpful tool in the transformation

process of traditional development-orientated IT departments to service-oriented internal suppliers of IT-enabled solutions.

The OGC promises a lot of benefits for companies that adopt the ITIL best practice framework like reduced costs, improved IT services through the use of proven best practice processes, improved customer satisfaction through a more professional approach to service delivery, standards and guidance, improved productivity, improved use of skills and experience, and improved delivery of third party services through the specification of ITIL or ISO 20000 as the standard for service delivery in services procurements (OGC 2007a).

Despite that, there is not much quantitative data to prove that those benefits can be realized in practice. But there are a few research papers that undertook a qualitative approach to determine the benefits that an adoption of ITIL can provide (e.g. Hochstein et al. 2005a, Cater-Steel et al. 2006, Potgieter et al. 2005). Two of these papers used case-studies to examine the result of ITIL implementations that have been successfully executed. Cater-Steel et al. (2006) examined five Australian companies that had implemented ITIL at least three years ago and found a number of benefits. These benefits are namely "improved focus on IT service management, more rigorous control of testing and system changes, more predictable infrastructure, improved consultation with IT groups within the organisation, smoother negotiation of SLAs [service level agreements], reduced server faults, seamless end-to-end service, documented and consistent IT service management processes across the organisation, effective CAB, and consistent logging of incidents" (Cater-Steel et al. 2006, p. 7). Another study identified "client/service orientation and the quality of IT services respectively", "efficiency due to standardization, optimizing of processes and process automation", and "transparency and comparability through process documentation and process monitoring" (Hochstein et al. 2005a, p. 5) as the major benefits that could be realised in six German companies. According to these two studies and the information published by the OGC we have now number of possible benefits.

The current ITIL v3 consists of 5 core books and one introductory book, while ITIL v2 consisted of seven core books. The ITIL v2 books are called service support, service delivery, ICT infrastructure management, planning to implement service management, application management, the business perspective, and security management. Most IT professionals that were involved

with ITIL focused on the use of the first two books, service support and service delivery. The five core books of ITIL v3 are Service Strategy, Service Operation, Service Design, Service Transition, and Continual Service Improvement. The introductory book is called the official introduction to ITIL service management. In addition there are a number of books to customize ITIL to the specific need of certain industries. These books provide guidance to convert innovative ideas and concepts into services for customers, to solve problems with effective and enduring solutions, to control costs and risks that can potentially destroy carefully created value, and to learn from successes and failures to manage new challenges and opportunities (OGC 2007c).

Figure 1 shows the service lifecycle depicted in the current ITIL v3 book series. It shows the relationship between the content of the five books. We can see that service strategy builds the centre of the service lifecycle. The next layer is build by service design, service transition and service operation. The outer layer is continual service improvement.

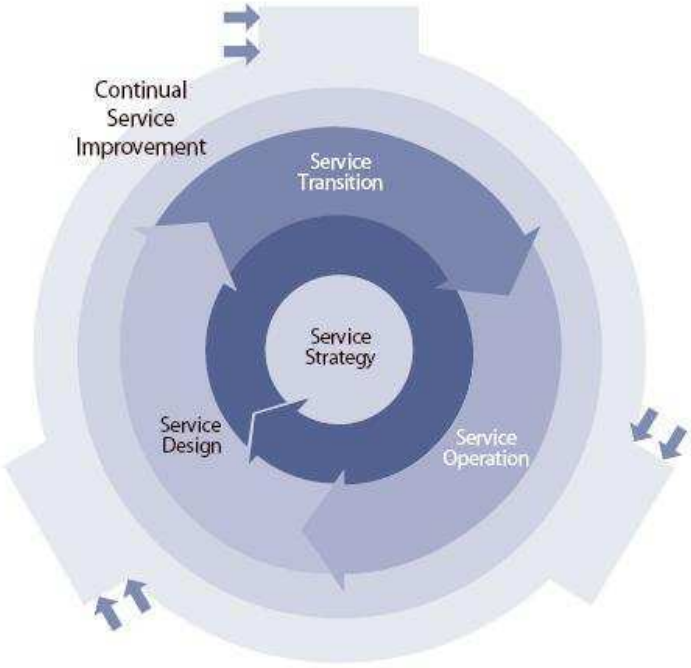


Figure 2.1: The ITIL Service Lifecycle (OGC 2007c, p.24)

The following sub-sections review specific details in each of the five ITIL books to provide a deeper understanding of what ITIL is and how it can be used to improve IT service management.

2.1.1 Service Strategy

"The Service Strategy volume provides guidance on how to design, develop, and implement service management not only as an organization capability but also as a strategic asset" (OGC 2007c, p.8). This book covers a lot of important service management topics, including development of markets, implementation of strategy through the service lifecycle, financial and service portfolio management, and organizational development among others. This book is also very useful to provide guidance in the context of the other four books, Service Design, Service Transition, Service Operation, and Continual Service Improvement. Organizations currently using ITIL can use this book as a tool to review and improve their service management strategies as well as the alignment between service management strategies and business strategies (OGC 2007c). In an ITIL service lifecycle context the service strategy volume forms the centre of the lifecycle. The strategy provides the basis of service design, service transition and service operation. One source of input to the service strategy is the continual service improvement process.

The Service Strategy volume contains 9 chapters. The usual Introduction chapter is followed by chapter two, which is called Service Management as a practice. Chapter two provides a general introduction to service management and contains a definition for the business process as well as a set of principles of good service management. It also introduces the service lifecycle and functions and principles across the lifecycle. In chapter three the focus is on service strategy principles. The principles discussed are grouped into value creation, service assets, service provider types, service structures, and service strategy fundamentals. Chapter four contains important steps for the creation of a service strategy. Namely these steps are the definition of a market, the development of the

offerings, the development of strategic assets, and the preparation for execution. Chapter five is concerned with service economics. The topics in this chapter area financial management, return on investment, service portfolio management, service portfolio management methods, and demand management. The focus of chapter six is on strategy and organization. Topics that are discussed include organization development, organizational departmentalization, organization design, organizational culture, and sourcing strategy. Chapter seven is called strategy, tactics and operations. The discussed topics include implementation through the lifecycle, strategy and design, strategy and transition, strategy and operation, and strategy and improvement. This chapter is especially interesting, because it provides a link between the service strategy volume and the other four books in the ITIL v3 series. It clearly defines the relationship between the different stages of the ITIL service lifecycle. Chapter eight is concerned with technology and strategy. The discussed links between technology and strategy include service automation, service interfaces, and tools for service strategy as well as a general outline of socio-technical systems. Chapter nine completes the book by adding information about challenges, critical success factors and risks. These include complexity, coordination and control, preserving value, effectiveness in measurement, and risks, which is concerned with service provider risks, contract risks, design risks, operational risks, and market risks. The appendix provides supplementary guidance with a description of asset types and a definition for the roles and responsibilities of a product manager.

Overall, the service strategy volume provides a general understanding of the service management environment and guidance for the development of a unique service strategy. It also provides a link to the other ITIL core books. This is probably the most important book of the ITIL v3 series, because service strategy builds the centre part of the service lifecycle on which ITIL is based on.

2.1.2 Service Design

“The Service Design volume provides guidance for the design and development of services and service management processes” (OGC 2007e, p.7). The purpose of this book is to provide guidance and best practices for the design of services that meet the expectations. Service design is defined as “the design of appropriate and innovative IT services, including their architectures, processes, policies and

documentation, to meet current and future agreed business requirements" (OGC 2007e, p. 223). The service design volume includes nine chapters.

After an introduction chapter, this volume provides information about services and service management as well as an outline of the service design fundamentals in chapter two. The key processes in this volume and the business value of this volume are also defined. Chapter three contains a number of service design principles. These principles include goals, balanced design, identifying service requirements, identifying and documenting business requirements and drivers, design activities, design aspects, which is by far the biggest part of this chapter, the subsequent design activities, design constraints, service oriented architecture, business service management, and service design models. In chapter four the focus shifts from the service design principles to the service design processes. The service design processes chapter is the main part of this volume. It defines processes for service catalogue management, service level management, capacity management, availability management, IT service continuity management, information security management, and supplier management. The main purpose of those processes is to provide information to the design of the services so that they meet all the requirements. Chapter five is all about Service Design technology-related activities. The topics contained are Requirements engineering, data and information management, and application management. Chapter six is called organizing for service design. Recommendations are made for a functional roles analysis, activity analysis, the skills and attributes recommended for people that are employed in service management positions, and the roles and responsibilities within the ITIL service management area. Chapter seven discusses technology considerations, especially service design tools and service management tools. In this context it is mentioned that it is important to align the tools with the processes without designing processes to fit to the established tools (OGC 2007e). Chapter eight is all about implementing service design. It outlines a whole implementation process that includes business impact analysis, service level requirements, risks to the services and processes, implementing service design, measurement of service design. It also addresses the issue of where to start with the implementation. Chapter nine provides information about potential challenges, critical success factors and risks. The appendix contains a lot of examples and additional information about the

introduced technologies, processes and practices. For example Appendix H provides additional information to the service management process maturity framework, which is aligned with the SEI's CMMI (OGC 2007e), and outlines the different levels of maturity.

To successfully design a new service it is important that all internal and external requirements and influences are clarified and clearly defined. There are a large number of influential external elements that need to be considered, like COBIT, CMMO, the Sarbanes-Oxley-Act (SOX), and the ISO standards (OGC 2007e). In an ITIL service lifecycle context the service design plays a major role. It is situated in the second layer of the lifecycle (see figure1). Its main sources of input are service strategy and continual service improvement. The output of service design is received by service transition. Service operation is linked to service design through service transition.

2.1.3 Service Transition

"The Service Transition publication provides guidance for the development and improvement of capabilities for transitioning new and changed services into operations" (OGC 2007d, p.6). Service Transition is, in an ITIL lifecycle context, the middle part between Service Design and Service Operation. It is not a standalone process. Its main purpose is to transform the concepts of the service design stage into services that can be used on a day-to-day basis by service operation.

The service transition volume is organized into nine chapters. The first chapter is the introduction which contains general information about ITIL and describes the goal and scope of service transition. Chapter two is called service management as a practice. It is concerned with service management and services in general and functions and processes across the lifecycle and service transition fundamentals in particular. It provides an understanding of the relationship between service transition and the other service lifecycle stages. The purpose of the principles is to enable organizations to implement the best practices in service transition. In chapter three the focus is on the service transition principles. The topics are principles supporting service transition and policies for service transition. Chapter four, which is by far the biggest part of the book, is concerned with the service transition processes. The processes are namely transition planning

and support, change management, service asset and configuration management, release and deployment management, service validation and testing, evaluation, and knowledge management. These processes link the service transition to service design, through evaluation, and to service operation, through performance testing. The fifth chapter is all about service transition common operation activities. This chapter includes managing communications and commitment, managing organization and stakeholder change, and stakeholder management. The difference between the processes and common activities is that the common activities are directly included in the service transition process. They mainly contribute to service transition or are supported by service transition. Chapter six is called organizing for service transition. It discusses generic roles, organizational context for transitioning a service, organization models to support service transition, service transition relationship with other lifecycle stages. It provides an outline of the major activities for the defined roles. The assignment of a service transition manager is described as a key activity (OGC 2007d). Chapter seven brings in technology considerations. Namely these are knowledge management tools, collaboration, and configuration management system. Technology has a huge impact on service transition and should therefore be designed in alignment with the service transition process.

The focus of chapter eight is on implementing service transition. This chapter contains an outline of the major activities that are required for a successful implementation of service transition best practices. These activities include the justification of service transition, the design of service transition, and the introduction of service transition. The activities should also cover cultural change aspects. To complete the book, chapter nine adds a list of challenges, critical success factors and risks. There are also some recommendations for service transition under difficult conditions like restricted resources or the need for speed. The appendices of the service transition book add descriptions of different asset types.

The service transition book builds a link between service design and service operation and provides recommendations for the transition of services. Its main focus is on the processes of the service transition stage. It is a key part of the ITIL v3 book series and the ITIL v3 service lifecycle. The main source of input is the Service Design volume with additional input from the Continual Service

Improvement volume. The main recipient of the outputs is Service Operation. But in addition, there is also output to the Continual Service Improvement stage that can include suggestions on required changes to processes defined in the Service Design stage or even in the Service Strategy stage of the ITIL product lifecycle (OGC 2007d).

2.1.4 Service Operation

The Service Operation "volume embodies practices in the management of service operations. It includes guidance on achieving effectiveness and efficiency in the delivery and support of services so as to ensure value for the customer and the service provider" (OGC 2007f, p.6). Its main purpose "is to coordinate and carry out the activities and processes required to deliver and manage services at agreed levels to business users and customers" (OGC 2007f, p.13). The service operation volume is important to the ITIL lifecycle because it provides guidance for the effective and efficient day-to-day operation of the previously designed and implemented services as well as a link to the continual service improvement stage.

This volume includes nine chapters. The first chapter is the usual introduction chapter. Chapter two provides an overview about services, service management, functions and processes across the lifecycle, and service operation fundamentals. It is called service management as a practice. In chapter three the principles of service operation are introduced. The first principal is functions, groups, teams, departments and divisions. Other principles are achieving balance in service operation, providing service, operation staff involvement in service design and transition, operational health, communication, and operation. Chapter four is about the service operation processes. The processes discussed are event management, incident management, problem management, access management, and operational activities of processes covered in other lifecycle phases. This chapter provides guidance for different day-to-day activities that are to be expected in service operations. In chapter five the focus shifts to common service operation activities with monitoring and control being the biggest part of the chapter. Other common activities include IT operations, mainframe management, server management and support, network management, storage and archive,

database administration, directory services management, desktop support, middleware management, internet/web management, facilities and data centre management, information security management and service operation, and improvement of operational activities. The main purpose of this chapter is to ensure alignment between technology and service objectives is achieved and maintained. Chapter six is all about organizing for service operation. The included topics are functions, service desk, technical operations, IT operations management, application management, service operation roles and responsibilities, and service operation organization structures. Chapter seven discusses technology considerations. These considerations are namely generic requirements, event management, incident management, request fulfilment, problem management, access management, and service desk. Chapter eight provides guidelines for service operation implementations. This includes managing change in service operation, service operation and project management, assessing and managing risk in service operation, operational staff in service design and transition, and planning and implementing service management technologies. The final chapter is called challenges, critical success factors and risks. This includes risks to successful service operations or even loss of services. The appendix includes complimentary industry guidance, which includes information about related frameworks and methodologies, and guidelines for communication in service operation, which describes the different occasions that require communication. It also contains Kepner and Tregoe's method to analyse problems, Ishikawa diagrams, a detailed description of facility management, and a chapter about physical access control.

In an ITIL service lifecycle context the service operation is in the middle layer (see figure1). Its main sources of input to service operation are service transition and design. There is also input from service strategy and continual service improvement. The major recipient of the output is continual service improvement.

2.1.5 Continual Service Improvement

The Continual Service Improvement (CSI) "volume provides instrumental guidance in creating and maintaining value for customers through better design, introduction, and operation of services" (OGC 2007g, p. 6). The main purpose of

CSI is to assure and improve the alignment between IT services and the corresponding business processes. The key process in this volume is the 7-step improvement processes. The seven steps in this process are to define what you should measure, to define what you can measure, to gather the data, to process the data, to analyse the data, to present and use the information, and to implement corrective action.

This volume includes nine chapters like the other four books. Chapter one is the introduction chapter and chapter two contains general information about services and service management. It also includes an overview about the continual service improvement fundamentals. Chapter three is called continual service improvement principles. It contains a number of topics including CSI and organization change, ownership, role definitions, external and internal drivers, service level management, the Deming cycle, service measurement, knowledge management, benchmarks, governance, and frameworks, models, standards and quality system. The Deming cycle follows the plan-do-check-act approach and is critical “in the implementation of CSIs, and for the application of CSI to services and service management processes” (OGC 2007f, p.29). Chapter four is all about continual service improvement processes. It introduces the 7-step improvement process. Other processes include service reporting, service management, return on investment for CSI, business questions for CSI, and service level management. Chapter five introduces continual service improvement methods and techniques. The included topics are methods and techniques, assessments, benchmarking, measuring and reporting frameworks, the Deming cycle, CSI and other service management processes, and a summary. Chapter six is about organizing for continual service improvement and contains information about roles and responsibilities that support CSI, the authority matrix, and a summary. Chapter seven discusses technology considerations, especially tools to support CSI activities. The categories of tools include IT service management suites, event management, knowledge management, performance management, financial management, and others. Chapter eight is called implementing continual service improvement and starts by discussing critical considerations for implementing CSI and by answering the question “Where do I start”. Other topics in this chapter are governance, CSI and organization change, and communication strategy and plan. It also contains a summary. Chapter nine completes the book by providing

information about challenges, critical success factors, and risks. The appendix offers complementary guidance to related frameworks and methods and how they can support the continual service improvement process.

This volume also states that it might not be easy to successfully implement CSI and that “it requires a change in management and staff attitudes and values that continual improvement is something that needs to be done proactively and not reactively” (OGC 2007f, p.168). Continual Service Improvement is a key part in the ITIL service lifecycle. It receives input from all service strategy, service design, service transition, and service operation. Recipients of the output are service strategy, service design, and service transition.

2.2 RELATED FRAMEWORKS

According to the OGC (2007a) ITIL is closely related to a number of other frameworks and standards. The related standards include the ISO/IEC 20000 and the ISO/IEC 27001. ITIL is also related to the IT Governance framework Control Objectives for Information and related Technology (COBIT). In a joint effort the ITGI and the OGC, with the support of the itSMF, published a document that provides a general overview of and mapping between COBIT, ITIL and the ISO 17799 standard (ITGI & OGC 2005). In addition ITIL is related to the Project Management methodologies Projects in Controlled Environments (PRINCE2) and Project Management Body of Knowledge (PMBOK). Other related methodologies include the Software Engineering Institute’s Capability Maturity Model Integration (CMMI), the OGC’s Management of Risks (M_o_R), the eSourcing Capability Model for Service Providers (eSCM-SP), the Telecom Operations Map (eTOM), and Six Sigma. In the following sub-sections COBIT, PRINCE2, PMBOK, the different CMMs, and Val IT are introduced in more detail. The ISO/IEC 20000 series will be discussed in the customer service sub-section that follows in more detail.

2.2.1 COBIT

COBIT (Control Objectives for Information and related Technology) was first developed by the Information Systems Audit and Control Foundation (ISACF), the research institute of the Information Systems Audit and Control Association

(ISACA). In 2003 ISACF changed its name to IT Governance Institute (ITGI). The first version of COBIT was published in 1996.Version 2 was published in 1998 and followed by version 3 in 2000 and version 4 in 2005. In May 2007 the current version 4.1 was released.

COBIT describes four different stages in the lifecycle of information systems. The four domains are Planning and Organise (PO), Acquire and Implement Automated Solutions (AI), Deliver and Support (DS), and Monitor and Evaluate (ME). In each domain COBIT describes a set of control objectives, which describe business processes that should be used, and control processes, which will help to manage and control the complexity of the IT structures as well as the rapid change the occurs in the IT environments (Debreceny 2006).

While ITIL focuses on IT Service Management, COBIT's purpose is to enhance IT Governance. ITIL provides companies with information about how it should be done rather than what should be done. To identify what has to be done to achieve IT excellence companies should implement COBIT (Robinson 2005; ITGI 2007).

The primary focus of COBIT is the alignment of the use of IT with business strategies to achieve the organizational goals. It is widely used in public and private sector organizations around the world. Especially in the area of financial organizations, there is a widely spread use of COBIT (Ridley et al. 2004). There are numerous reasons why COBIT is so widely accepted. One of the more important reasons is that COBIT is open standard and free of any costs. The importance of COBIT also increased with the passage of the Sarbanes-Oxley Act in 2002. This act requires the use of a suitable control framework to evaluate an organization's Internal Control over Financial Reporting (ICFR) and COBIT is suitable for the evaluation of IT Controls (Debreceny 2006).

COBIT Management Guidelines also include a unique Capability Maturity Model (CMM) that will be introduced in more detail in section 2.3.4.4.

2.2.2 Val IT

Val IT is also an initiative of the ITGI. The main purpose of Val IT is to assist organizations in maximizing the value of the IT investments. The ITGI argues that "Val IT, supported by the control framework in COBIT, provides a one-stop, credible and codified source to support the creation of real business value from

IT-enabled investments" (ITGI 2006, p. 7). Val IT complements COBIT rather than concurs with it. While COBIT focuses on the execution, Val IT's focus is on the investment decisions and realisation of benefits. ITGI argues that a complementary adoption of Val IT means greater chances to increase the overall value of IT for the organization (ITGI 2006). Val IT follows a set of principles applied in value management processes and its outcome can be measured by key performance indicators.

Val IT will help to realise the benefits of IT investments through "increasing the understanding and transparency of costs, risks and benefits and the probability of selecting those investments with the highest potential return". It will also "increase the likelihood of success of executing selected investments such that they realise or exceed the expected return" (ITGI 2006, p. 8).

Currently the focus of Val IT is mainly on IT-enabled investments, but the ITGI intends to expand Val IT in the near future so that all IT areas and services are covered by it.

2.2.3 PRINCE2

PRINCE2 (Projects in Controlled Environments) is one of the major project management methodologies alongside PMBOK (see section 2.3.4). PRINCE was initially developed in 1989 by the Central Computer and Telecommunications Agency (CCTA) of the UK Government as an IT project management methodology. PRINCE2 was released in 1996 as a more generic project management methodology. Today PRINCE2 is maintained and improved by the OGC.

PRINCE2 uses a process-driven method and is divided in 8 major processes. According to Bentley (2001), each process describes when and by whom something should be done and defines exactly what the action should look like. The processes follow a logical order and start with the starting up a project (SP) process that is followed by the initiating a project (IP) process. Subsequent processes are controlling a stage (CS), managing product delivery (MP), managing stage boundaries (SB), and closing a project (CP). The remaining two processes, directing a project (DP) and planning (PL), continue through the whole project. Each of these processes now has a number of sub-processes, which

describe the actions that should be taken to fulfil that step of the project in more detail. PRINCE2 has a total of 45 sub-processes.

Each project that runs under PRINCE2 should include all eight processes in some fashion. Despite that each project is unique and organizations should carefully examine and evaluate the methodology and tailor it to the specific project needs (Bentley 2001).

Today PRINCE2 is the de facto standard for project management in the UK and 50 other countries worldwide (OGC 2008). According to the OGC (2008), "PRINCE2 is recognized as a world-class international product and is the standard method for project management". It is widely adopted in private and public sectors and can be applied to any type of project unlike PRINCE, who was developed to be an IT project management methodology (Bentley 2001).

2.2.4 PMBOK

The Guide to Project Management Body of Knowledge (PMBOK® Guide) is not strictly a project management methodology like PRINCE2 but more of a process-driven guide that provides the required information to develop individual methodologies. It was first published in 1987 by the Project Management Institute (PMI). The latest publication was the version 3 published in 2004. PMI describes the project management body of knowledge (PMBOK) as "the sum of knowledge within the profession of project management" (PMI 2004). To establish their own project management methodology, organizations should use "A Guide to Project Management Body of Knowledge (PMBOK® Guide)" published by the PMI to identify the best practices in project management.

The PMBOK® Guide is organized into three different sections. These sections are called the project management framework, the standard of project management of a project, and the project management knowledge areas.

The project management framework "provides a basic structure for understanding project management" (PMI 2004, p. 9), while the section two, the standard of project management of a project, "specifies all the project management processes that are used by the project team to manage a project" (PMI 2004, p. 9).

In section three the PMBOK® Guide recognises five basic groups of processes and nine knowledge areas. The five basic processes are initiating,

planning, executing, controlling and monitoring, and closing. The nine knowledge areas recognised in PMBOK® are project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communications management, project risk management, and project procurement management. PMBOK also identifies 44 processes that each belong to one basic group and one knowledge area. The result is a matrix representation that links processes, basic groups and knowledge areas.

2.2.5 CM

This sub-section presents literature on the capability maturity models that are currently in use. The Capability Maturity Model (CMM), the Capability Maturity Model Integration (CMMI), the capability model of the ISO/IEC 15504 standard, which is also called Software Process Improvement and Capability Determination (SPICE), and the COBIT 4.1 capability maturity model are described in more detail below in the respective sub-section.

2.2.5.1 CMM

The Capability Maturity Model was developed by the Software Engineering Institute (SEI) of the Carnegie Mellon University. The major intention was to offer software organisations a tool to improve their software processes.

The CMM is organised into five maturity levels. Level one is called “Initial” and describes a status where most of the software processes are characterised as ad hoc and few processes are defined at all. Level two is called “Repeatable” and is meant to describe the ability of companies to repeat successful projects through the use of basic project management processes. “Defined” is the third level that uses a standardized software process for management and engineering activities. The forth level is called “Managed” and describes an organisation where level three is enhanced by detailed measurement of processes and products. The fifth and final level is called “Optimising” and requires continues process improvement and piloting innovative ideas and technologies in addition to the other requirements.

2.2.5.2 CMMI

The Capability Maturity Model Integration (CMMI) is a successor of the CMM. It was developed by members of Industry, Government and the SEI. The version 1.1 was first released in 2002 and was followed by version 1.2 in 2006.

The goal of the CMMI was to incorporate the CMM's by integrating different models into one framework. The initial approach was to integrate three popular source models, the Capability Maturity Model for Software (SW-CMM), the Systems Engineering Capability Model (SECM), and the Integrated Product Development Capability Maturity Model (IPD-CMM), into one framework. (SEI 2006).

2.2.5.3 SPICE or ISO/IEC 15504

Software Process Improvement and Capability Determination (SPICE) or ISO/IEC 15504 is a framework for assessment methods. It was developed by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) in a joint effort and was originally derived from the SEI's CMM and the process lifecycle standard ISO 12207.

SPICE uses a reference model to link the process dimension with the capability dimension. There are a number of defined processes that are rated on the capability scale. SPICE uses a zero-based 6 point scale to express the capability of the defined processes. In ascending order, the scale levels are called incomplete process, performed process, managed process, established process, predictable process, and optimizing process. The capability of processes can be measured through attributes. SPICE defines nine different attributes that are attached to five of the six scale levels. The level zero has no attached attributes and level one has just one attribute while levels two to five have two attributes each. The attribute for level one is called Process performance. The attributes for level 2 are Performance Management and Work Product Management. Process Definition and Process Deployment are the attributes of level three. The level four attributes are called Process Measurement and Process Control. Attached to level five are Process Innovation and Process Optimization. Finally each of these attributes is rated on a four-point scale to determine the final capability level of each process.

2.2.5.4 COBIT 4.1

COBIT's Maturity Model is directly derived from the SEI's CMM (Debreceny 2006), except that COBIT uses a zero-based 6 point scale instead of the one-based 5 point scale in the CMMs. The additional zero describes a state where the capability of an organization to fulfil actions in a certain area is non-existent. According to Debreceny (2006) the CMMs are one of the major parts of COBIT and also one of the reasons for its current success.

2.3 PERSPECTIVES OF CUSTOMER SERVICE

The Institute of Customer Service (ICS) defines customer service as "the sum total of what an organization does to meet customer expectations and produce customer satisfaction" (ICS 2008, p.1). Customer service includes internal customers as well as external customers that are connected to an organization in any way. In my case the customers are defined as clients that are connected to an organization's IT department or to any IT-enabled services. The IT department is seen as a service provider to the employees, suppliers and customers.

Hochstein et al. (2005a) claims that the current relation between IT departments and internal customers seems to become more and more like a traditional client-supplier situation, where the internal IT must face its external competitors. They also found that reference models are a helpful tool in the transformation process of traditional development-orientated IT department to service-oriented internal suppliers. Prior research found that a higher level of IT planning, control, organization, and integration can improve an organizations customer service and that especially a high level of IT organization and control is necessary to achieve an IT-enabled customer focus. (Karimi et al. 2001). Internal IT services can include for example the provision of IT enabled solutions, IT helpdesk, or the development or customization of software. External IT services can include a variety of services, like online sales solutions, integration of customer in supply chains, or simply the provision of information about products and services.

An important role in customer service, especially in an information technology context, plays the ISO/IEC 20000 series, which is derived from the BS 15000. It is the first international standard on for IT service management. The ISO/IEC 20000 series consists of two major parts. The first part, called ISO/IEC

20000-1:2005, outlines the specifications and is concerned with the requirements of organizations to provide managed services for its customers. The second part, called ISO/IEC 20000-2:2005, is a code of practice. Its main purpose is to provide organizations with information to the best practices in service management. The OGC describes the relationship between ISO/IEC 20000 and ITIL in the way that "ISO/IEC 20000 provides a formal and universal standard for organizations seeking to have their service management capabilities audited and certified. While ISO/IEC 20000 is a standard to be achieved and maintained, ITIL offers a body of knowledge useful for achieving the standard" (OGC 2007c, p. 7).

2.4 BUSINESS VALUE

IT can add value to the business in a number of different ways. For example, the potential business value of IT includes the capability to enhance product variety, faster development of new products and reduced error rates (Luftman et al., 1993). Luftman et al. (1999) also found that it is more likely that it is "the enhancement of distinctive capabilities through information that will provide the most value to the business"

An important factor to create value from IT investments is to ensure that IT strategies and business strategies are aligned (e.g. Henderson et al. 1993; Luftman et al. 1993; Luftman et al. 1999). Most of the alignment models we can see today are based on the initial model developed by Henderson et al. (1993) which created much interest in this area.

To determine the business value of ITIL we have to look at the benefits that organizations hope to achieve when adopting the ITIL framework. As we learned in Chapter 2.1, the OGC promises a lot of benefits for companies that adopt the ITIL best practice framework like reduced costs, improved IT services through the use of proven best practice processes, improved customer satisfaction through a more professional approach to service delivery, standards and guidance, improved productivity, improved use of skills and experience, and improved delivery of third party services through the specification of ITIL or ISO 20000 as the standard for service delivery in services procurements (OGC 2007a).

We also learned that another major advantage of an ITIL adoption is the fact that ITIL enables the IT departments to react faster to changed business needs

(Murray et al. 2007) and the fact that “customer satisfaction and operational performance improve as the activities in the ITIL framework increases“ (Potgieter et.al. 2005, p. 166). In addition to these benefits Hochstein et al. (2005b) identified ITIL as a reference model that can help to reduce costs and risks in the restructuring process from development-orientated to service-orientated IT departments.

Other studies identified “improved focus on IT service management, more rigorous control of testing and system changes, more predictable infrastructure, improved consultation with IT groups within the organisation, smoother negotiation of SLAs [service level agreements], reduced server faults, seamless end-to-end service, documented and consistent IT service management processes across the organisation, effective CAB, and consistent logging of incidents” (Cater-Steel et al. 2006, p. 7) as well as “client/service orientation and the quality of IT services respectively”, “efficiency due to standardization, optimizing of processes and process automation”, and “transparency and comparability through process documentation and process monitoring” (Hochstein et al. 2005a, p. 5) as the major benefits that could be realised in companies that use ITIL.

There are some benefits included here that can directly enhance the financial results of a company, like reduced costs. Other benefits will add value to business through more indirect channels, like improved customer satisfaction and improved customer service. Overall most of these benefits, if they can be realised, will clearly have a very positive effect on an organizations performance and results.

2.5 CONCLUSION

The literature review above provides an overview of the context of this thesis so that the area and subject is defined. The main topics are ITIL, especially the Version three, including the five ITIL core books, and the related frameworks. Other topics of related interest include business value and the perspectives of customer service.

This chapter gives a lead into identifying areas in which the possible benefits of the use of the ITIL framework can be found. Furthermore, the understanding of the relationship between ITIL and related frameworks and

methodologies, like COBIT, PRINCE2, PMBOK, Val IT, and the different CMMs have been noted. The potential business value of IT control and service management frameworks is a more difficult problem area and deserves further investigation. Also the relationship between customer service and business benefits is a related problem area.

The relevant research question that fits both problem areas would be:
What are the perceived benefits for customer service of the use of ITIL?

The next chapter will introduce a review of similar studies and the methodology to answer this question, the approach and limitations of the selected methodology.

Chapter – 3 Research Methodology

3.0 INTRODUCTION

The previous chapter has identified the relevant literature that is concerned with the topic for research. The benefits of ITIL use were identified and grouped into different clusters. The relationship between IT service management and customer service was also identified. Furthermore the impact that ITIL and customer service can have on the business were reviewed. The literature review delivered a researchable question but did provide guidance as to how to develop a research model and the appropriate research instruments to test a model. Data and its collection also were not defined in the theory review.

In this chapter a research framework is developed and a research model defined. In the first step five similar studies are reviewed to identify the research methodologies used by other researchers in their studies. These studies were chosen because they show significant similarity with different aspects of this thesis. The next step is to design the research framework to be used. In this step the previously reviewed publications and Chapter 2 reviews will be taken into account. There is also an outline of the main research instrument used to obtain the data sample. Next the research model will be created and hypotheses are defined for the proposed relationships of the observed variables. Then the data requirements will be outlined in detail. Finally the limitations of the research methodology will be mentioned and a conclusion and summary of this chapter presented.

3.1 SIMULATION THEORY

“A simulation is a functional model that imitates the behaviour of a reference system” (Klabbers et al. 2006, p.ix). In current and past research projects simulation has often been used in cases where real-life experiments could be dangerous or difficult to perform. Another case where simulation is a useful tool is when real-life data can hardly be collected. In that case a simulation can be used to generate a data sample that represents the expected real-life data.

In this case it is predicted that access to the quality of data required to answer the research question would be difficult and the time required may be greater than that available.

In general a simulation uses a model of an actual object and performs a certain action on the model to determine the behaviour of the actual object under different circumstances. The model that is used has to be an image of a real-life reference system with attached rules of interference for the included variables. The major benefits that can be gained through simulation include the possibility to observe whole systems instead of examining small part of these systems. In addition simulation can be used to optimize the performance of a model and draw conclusions on how to improve the real-life system.

Other benefits include higher cost efficiency. In general simulation is much cheaper than field work, because no special expenses are required. Today even the most of the complex simulations can be performed on PCs. Another benefit is the time efficiency. As mentioned above simulations can be performed on a private computer, and no special conditions have to be considered. In addition no time to wait for responses is required.

Last but not least simulations are easily repeatable and allow therefore a broader range of usability. For example different vendor products could be tested under the exact same conditions. The next two sub-sections report progress in improving the generality of simulation and the account of possibilities for complex agent contexts.

3.1.1 From Math Models to Agent Theory

A model is an image of an actual object. One condition that applies is that the rules of correspondence are defined. These rules state how the image has to be interpreted to be a model of the original object (Klabbers et al. 2006). There are a number of different types of models. These include quantitative and qualitative models. Klabbers et al. (2006) defines the difference of these two types as qualitative being only able to measure the value of the attributes in relation to each other while quantitative being able to measure absolute values and changes over time.

Each of these types of model has a number of subtypes, including mathematical models as subtypes of quantitative models.

In Figure1 a representation of a model cycle developed by Klabbers et al. (2006) is elaborated. This model cycle illustrates the processes involved in model building. The model is the image of an actual reference system. The reference system and the disciplinary rules of interference together with the information and data needs can be seen as the input to the model. Methods, techniques, and instruments are the tools required to perform the model building and to carry out the experiment. Data analysis is another tool to evaluate the result of the experiment and to provide information for the conclusions. The knowledge gained in the whole process will increase the knowledge about the reference system.

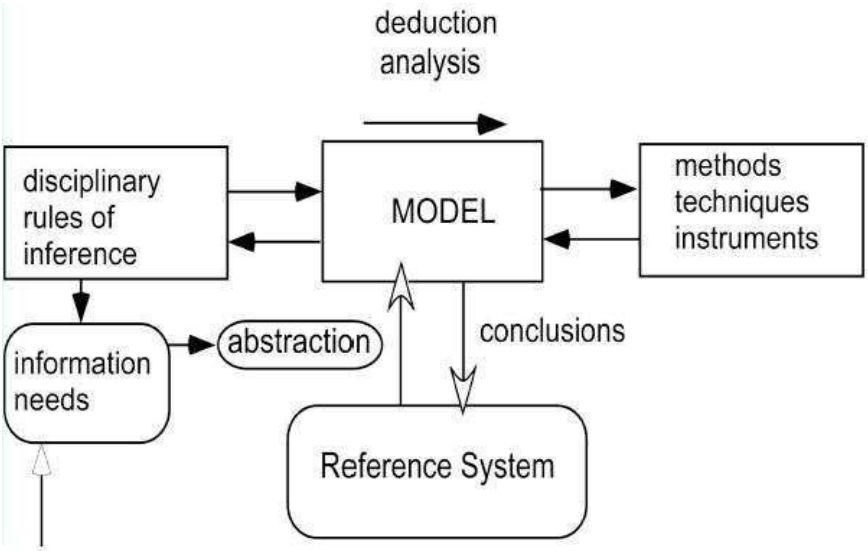


Figure 3.1: Representation of the model or empirical cycle (Klabbers et al. 2006, p.106)

Klabbers et al. (2006) identifies two major phases in the model development process. The first step would be to “frame the conceptual system of feedback loops” (Klabbers et al. 2006, p.108). The second step is the mapping of that system into a flow diagram of the mathematical model.

There are also a number of different generic systems that are being used in model building. These systems include descriptive and normative systems. Both systems are basically input-output systems with defined throughput mechanism.

In addition to the basic functionality the normative system has a so-called agent implemented as internal mechanism. This agent based system is mainly used to improve the performance of a system (Klabbers et al. 2006).

In addition to the distinctions made above there is a classification of models by Randers (1972). He defined four classes of model maturity. In class 1 all assumptions that were used to develop the model are based on the creator's intuition or general knowledge about the reference system. Class 2 models are based on the consensus among experts and the relevant literature in addition to the requirements for Class 1. Class 3 adds formal techniques that allow demonstrating the capability of the assumptions to generate real-world data. In Class 4 the additional requirement is made that the model has to be able to reproduce the behaviour of the reference system.

3.1.2 Games

The games theory is an advancement of the traditional simulation methodology. According to Klabbers et al. (2006) gaming methodology offers a broader scope and enhances the simulation theory by other theories of knowledge. Furthermore it is said that games are not confined to one discipline but rather cross different disciplines. Referring to distinctions made in the previous chapter between the different generic systems, gaming has to be allocated to the normative systems. To take full advantage of this methodology this circumstance has to be considered in the design and assessment stage of the gaming cycle.

During the game design process a number of questions have to be addressed in order to improve the validity of the model or game as representation of an actual reference system. The answers to these questions have to determine the client, the purposes of the game, the subject matter, the intended audiences, and the context of use. Furthermore it is crucial that the participants are aware of any rules and restrictions concerning the process of gaming.

The participants of the gaming exercises will profit by building knowledge about their behaviour, both individual and as a group, and the impact they have on the behaviour of the system. If the game was designed as a model of a social system, these conclusions will have an impact the representing reference model (Klabbers et al. 2006).

Figure 3.2 shows the adjusted model cycle (see Figure 3.1), now called game design cycle (Klabbers et al. 2006). The major difference is the decomposition of the initial reference system into a referential and a self-referential system. These two systems are interconnected. Another difference is the switch from disciplinary rules of interference in the model cycle, to transdisciplinary styles of reasoning in the gaming cycle.

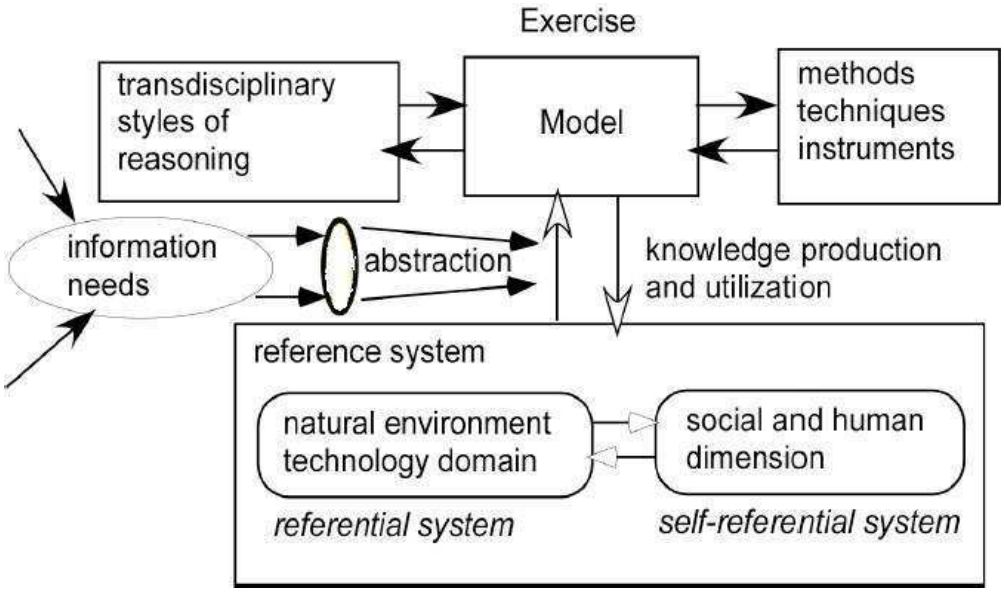


Figure 3.2: Representation of the game design cycle (Klabbers, 2006, p.125)

3.2 REVIEW OF PREVIOUS STUDIES

In this section five studies are reviewed to identify how other researchers chose and explained their research methodologies. These studies were selected because of their similarities with this research project. All of the studies us a quantitative approach to gather their data.

The first study by Hogan (2001) is concerned with the creation of a new construct to measure the creation of value in business-to-business relationships. This study uses a Monte-Carlo simulation to test the research model. The second study by Karimi et al. (2001) tried to identify the impact of IT sophistication on customer service in organizations where IT has a key role in marketing and operations. To test their hypotheses they used a survey approach issuing a questionnaire to over 1000 IT senior executives in financial organizations.

The third study was written by Brush et al. (1997) and the intention was to compare different indicators of the importance of a particular effect on the profitability of business units. The research methodology consisted of a Monte Carlo simulation approach. Vickery et al. (2003) wrote the fourth study that is reviewed in this chapter. Their main purpose was to establish a relationship between supply chain management, customer service, and the financial performance of organizations. They used a survey to obtain their data and sent questionnaires to 150 CEOs of supplier companies in the US automotive industry. In addition they used a simulation to validate their research model. The last study in this chapter was written by Tallon et al. (2000). The main purpose of this research was to develop a process-oriented model that is able to assess the impact that information technology has on critical business activities within an organization's value chain. They used a survey approach and sent questionnaires to approximately 1500 companies worldwide.

Reviews of each follow in the sub-sections below.

3.2.1 Expected Relationship Value

The first study to be reviewed in this chapter is called "Expected Relationship Value: a Construct, a Methodology for Measurement, and a Modelling Technique" and was written by John E. Hogan in 2001. The main purpose of this study was to "propose a new construct, expected relationship value, and an innovative method for its measurement" concerning the creation of value in business-to-business relationships. They developed a construct called expected relationship value (ERV) that is able to assist management in measuring the value of relationships with other businesses (Hogan 2001). The similarity to my research is the fact that they created a linkage between quality constructs and a value creation variable.

His research methodology consisted of four major stages, called identification of value centres, assessment of uncertainties, modelling the relationship, and analysing key variables. He conducted a series of structured interviews with the intention to "systematically capture the embedded organizational knowledge of the relationship" (Hogan 2001, p.342) between the involved organizations and their partners.

The data that he derived from the interview was then used to define the range of values for each variable in his ERV model. This model was than tested by using a Monte-Carlo simulation. The output of this simulation provided him with a value for the relationship between the two involved organizations. This simulation step was then repeated over multiple trials to estimate a probability distribution of the estimated relationship value.

3.2.2 Impact of IT management practices on customer service

The study is written by Karimi, Somers and Gupta in 2001. The title of this publication is “Impact of Information Technology Management Practices on Customer Service”. The main purpose of their publication was to identify if there are different IT management practices in use in organizations where IT has a key role in marketing and/or operations. They found that IT-leader firms (firms where IT has potentially a high impact on marketing and operations) have a higher IT management sophistication and are able to improve their customer service through a number of IT-based solutions.

They started by developing 4 hypotheses from an extensive literature review. The study hypothesised that there are differences in IT planning, control, organization, and integration between companies that have a different level of sophistication toward information technology. They used a quantitative approach in their data collection process and their research was of exploratory nature. They send questionnaires and a letter of explanation to over 1000 senior executives of IT departments at financial sector organizations. They measured the responses to their questions using a 5-point Likert scale. The response rate was approximately 21 percent. They used coefficient alpha to assess the reliability of their measures. They included several measures to validate their research instrument. First they pre-tested their questionnaire with a data sample obtained from 21 randomly selected companies in the financial sector. They excluded these companies from further analysis. Then they conducted over one dozen semi structured interview with IT senior executives for further validation of their questionnaire. They finally held a research workshop with colleagues to receive further input for possible improvements in the study and the instruments used.

A one-tailed t-test was used to test the convergent validity and validity was achieved. To test the discriminant validity they analysed bivariate correlations between each of the scales and compared the average interscale correlations to the Cronbach Alphas. They also established construct validity by testing wether all items in a scale contributed to a single factor. They could confirm their entire hypotheses with the results of their data analysis.

3.2.3 Corporate and Business Effects

This study is called “What does a small corporate effect mean? A variance components simulation of corporate and business effects” and was written by Brush and Bromiley in 1997.

The main purpose of this study was to compare different indicators of the importance of a particular effect on the profitability of business units. Their focus was on variance components estimates. They found that these estimates are not linear indicators of the importance of different factors and their contribution to the profit generation process. With their research they also took position to a widely cited publication by Rumelt (1991).

The methodology they used to test their hypotheses was a simulation approach using the SAS procedure Proc Varcomp to generate their estimates for their math models. They used a customized Monte Carlo method to generate their initial input data and tested three different models that they created from an extensive literature review.

These models represented the different assumptions of relationships between the corporate effect and the business units. In addition they implemented a sensitivity analysis to improve the results of their simulation. They also limited the number of effects in their simulation to two, the corporate and the business unit effect.

The justification for that is that additional effects would not generate additional value for their purpose. Their presentation of the empirical result included an investigation of the distribution of the generated estimates to ensure the reliability of the results. They concluded that a lot of the assumptions made by Rumelt (1991) are premature and not conclusive.

3.2.4 Effect of IT on Customer Service and Financial Performance

This study was written by Vickery, Jayaram, Droge and Calantone (2003). The title of the study is “The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships”. The author chose the study although it is concerned with supply chain strategies, because it has a huge similarity with the thesis in a way that both studies are trying to examine a relationship between a certain area in the IT field, customer service and financial performance or in my case business value. The main purpose of their study was to examine the implications of supply chain strategies on customer service performance followed by financial performance. They found that customer service is a full mediator between information technology and financial performance.

The authors proposed a research model with 4 variables and defined hypotheses for three direct relationships and one indirect relationship between these variables. They used a quantitative approach to obtain their data sample. As respondents they chose the CEO’s of the top 150 independently owned first tire suppliers of the Big 3 in the North American automotive industry. They received 57 responses and a response rate of about 38%.

To validate their research instrument they used a panel of experts as first step. Throughout their questionnaire they used a seven-point scale for all items. They also obtained actual values for the financial performance of the organizations and performed correlation testing of subjective measures versus actual values and found that the subjective measures are sufficiently valid indicators. They also performed a confirmatory factor analysis to verify their measures and achieved positive results for convergent, discriminate and construct validity. To evaluate the overall model fit they had to use simulation analysis because of their small sample size. They found the fit of the initial model as satisfying. They also found support for all hypothesised direct relationships but no support for the indirect relationship between supply chain integration and financial performance.

3.2.5 Information Technology and Business Value

The fifth and final study that is reviewed in this chapter was written by Tallon, Kraemer and Gurbaxani (2000). The title of this publication is “Executives’ Perceptions of the Business Value of Information Technology: A process-oriented Approach”. The main purpose of this research was to develop a process-oriented model that is able to assess the impact that information technology has on critical business activities within an organization’s value chain. One of their findings was that management practices such as strategic alignment lead to a higher perceived levels of IT business values.

This research project used a quantitative approach for the data gathering. They defined 6 hypotheses that were concerned with possible benefits of more focused goals for IT and the impact of better evaluation techniques. To create their data sample they sent questionnaires by mail to approximately 1500 companies worldwide. These companies were listed or similar to those listed in the Fortune 1000. Their target audience included but was not restricted to the business executives of those firms. They received 304 responses with an overall response rate of 20.3 percent.

To determine if their responses varied by different factors, like location or size, they used a one-way analysis of variance and found no significant differences. They used a seven-point Likert scale in their questionnaire. They classified the organizations into four groups according to their responses. These groups represent the level of sophistication that the organizations showed in the context of IT impact on operations and marketing. To validate these grouping they used a discriminant analysis. After performing factor analysis and reliability measures they formed composite variables for six critical business activities. Finally they tested if there were differences in realizing the IT impact using a one-way analysis by focus groups. They found that the perceived realization of IT business benefits is directly related with the level of sophistication an organization shows towards IT. They also found that organization perceive benefits from IT mainly in those areas where they want their IT departments to focus on.

3.3 THE RESEARCH DESIGN

This section is concerned with the design of the research. First the learning and valuable input from the previous section is reviewed. Therefore the methodologies are compared and the methodology for this research is selected. An introduction to the Monte Carlo method is given and its proposed use specified. In conclusion information to the hypotheses and the initial research model are given.

3.3.1 Review of Learning from Previous Studies

The review of previous studies shows that there is not one single approach that can be identified as the best approach to perform research in the IS field. All reviewed studies take a quantitative approach for data gathering and processing. While some studies (Tallon et al. 2000, Karimi et al. 2001, Vickery et al. 2003) use a survey as instrument for the data gathering process the other studies (Brush et al. 1997, Hogan 2001) use a simulation approach based on a Monte-Carlo method to generate their data sample. In addition Vickery et al. (2003) used a survey to gather their data sample and a simulation to determine the fit of their research model. Unfortunately they did not specify what kind of simulation they used and how they implemented that process into their methodology.

The three studies that used a questionnaire as a tool to gather the data sample implemented a mostly similar research methodology. They used an expert group for a first evaluation of their questionnaire and to identify major issues. Subsequently they performed a pilot study to gather a data sample to test and improve that scales of their questionnaire. The next step was to issue their questionnaire to the potential respondents. Finally they used the same statistic measures to evaluate the final data sample. As mentioned above Vickery et al. (2003) had to use a simulation to determine the fit of their proposed model because of their relatively small sample size.

The two studies that used a simulation approach also followed a slightly different methodology. While Hogan (2001) based the range of values and the distribution of these on information gathered mainly through structured interviews, Brush et al. (1997) defined their distributions through review of previously done studies in their area.

In addition Brush et al. (1997) used a sensitivity analysis and tested different model to identify the most likely case.

In this thesis a simulation using Monte-Carlo method for generating a random data sample is used. The decision to use this method is based on the opinion of the author that it would have been very difficult to obtain the required number of participants for the survey approach with expertise in the field of IT service management area. Lowering the standard of required knowledge concerning ITIL and IT service management for participation in the survey would have been inevitable. Therefore a simulation approach seems to be the best approach.

3.3.2 Monte Carlo Method

The idea of the Monte-Carlo method is to generate random numbers for variables in a system so that it can be tested without a real-life data sample. The term Monte-Carlo in the context of research simulation was first used by Metropolis and Ulam (1949).

To generate a data sample that is relevant, a justified statistical distribution of the estimates has to be applied to the specific variables. To determine the best shape for the statistical distribution that should be comparable with real-life data, a number of available resources, including previous studies, market research, or expert knowledge, are to be reviewed. Sensitivity analysis with worst case, best case, and expect case scenarios has to be considered. Sensitivity analysis will be discussed in more detail in section 3.5.4.

The Monte Carlo method is widely accepted and used in research where it is not possible to obtain a real-life data sample. Research areas that often make use of simulation methods include medicine, physics, industry, chemistry, and mathematics. More recently simulation has been developed to include multi agent games and the simulation of social realities (Klabbers et al. 2006).

One of the major advantages of the Monte Carlo method for generating random data samples is its simplicity. While other methods are often much more sophisticated without adding additional value to the research, Monte Carlo simulation is focused on the core points of using simulation as a methodology in research. It also provides flexibility where complexities can be sequenced

(layered) or weighted in keeping with the interaction of variables and values tradeoffs.

3.3.3 Research Design

The previous sections were used to identify the current literature, a number of similar studies and the methodologies that they used to gather the data sample for their research, and other considerations that were taken into account with the design of the research methodology. This section defines the research model and the hypotheses that will be tested against the created data. Therefore the factors identified in the literature review and the reviews of similar studies are taken into account. The proposed relationships between the variables identified by previous studies are also considered.

These reviews enable the identification of the main benefits that the use of ITIL promises. Those benefits that are able to influence customer service were selected. It was also considered how ITIL can be used to generate business value. The main research question for this thesis is stated below.

Q1: What are the perceived benefits for customer service of the use of the IT Infrastructure Library?

The literature that has been reviewed in the previous chapters allows researchers to make assumptions concerning the relationships between the constructs and variables involve in the problem area. The reviewed literature suggests that the use of ITIL will improve the provision of IT services, like help desk operations. Therefore we can define hypothesis 1:

H1: The use of ITIL will improve customer service through improved reliability of internal IT services.

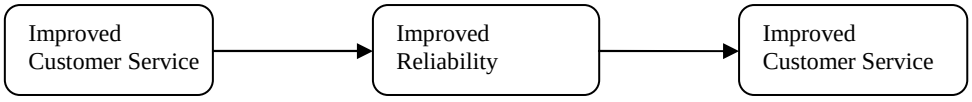


Figure 3.3: Hypothesis One

In addition other literature suggests that the use of ITIL also has a beneficiary effect on the consistency of IT services. This will lead to an improvement in customer service. Therefore we can formulate hypothesis 2 as follows:

H2: The use of ITIL will improve customer service through higher consistency of IT services.

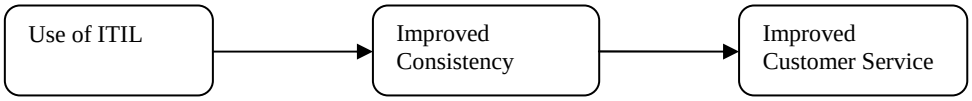


Figure 3.4: Hypothesis Two

The literature also suggests that ITIL will improve the overall quality of services. An improved quality of services should improve customer satisfaction directly. Therefore hypothesis 3 is defined in the following way:

H3: The use of ITIL will improve customer service through an improved efficiency of IT services.

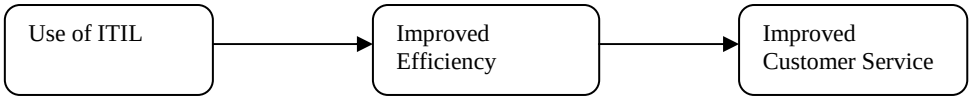


Figure 3.5: Hypothesis Three

I have also learned from previous research that the use of ITIL leads to a higher client orientation of the IT departments and the services that they provide to internal and external customers. Therefore we can hypothesis that

H4: The use of ITIL will improve customer service through a higher client orientation of IT departments and the services that they provide.

Figure 3.6: Hypothesis Four

Finally the literature suggested that improved customer service can create value to the business and that ITIL is able to improve customer service. So the final hypothesis is formulated as follows:

> H5: The use of ITIL will create value to the business through improved customer service.

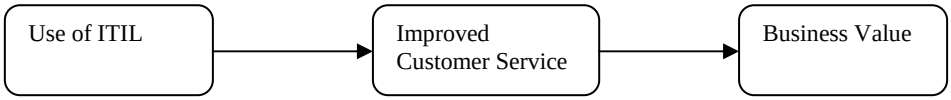


Figure 3.7: Hypothesis Five

The initial research model can now be constructed. It is expected that the use of ITIL has a beneficiary effect on service reliability and consistency, improves the quality of those services, and enables a higher client orientation within the IT departments and their provided services. These four factors will lead to an improved customer service. The final assumption is that the ITIL-enabled and improved customer service will provide value to the business. The research model is a combination of all assumptions and looks as follows.

Furthermore service reliability, service consistency, service efficiency, and client orientation are treated as independent variables to simplify the proposed models.

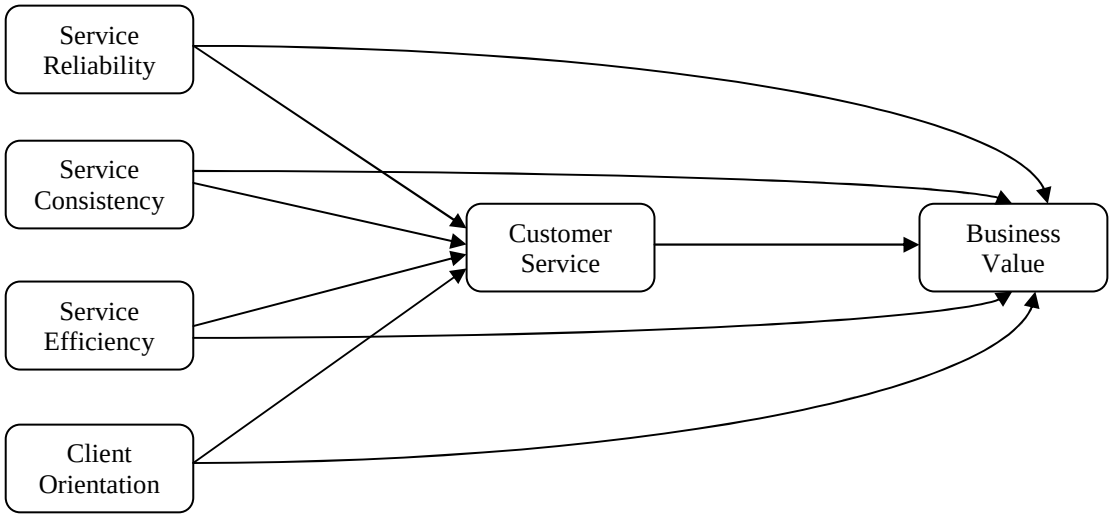


Figure 3.8: Initial Research Model

3.4 DATA REQUIREMENTS

This section is concerned with the data requirements for testing the model. It contains an outline of the different path models that can be derived from the initial model developed in section 3.3.3. These path models are based on the different roles of customer service. Next the metric model for each of the proposed path models is developed and justified. Justification of the estimates is based on the reviewed literature. The next section contains information to the constraints of the proposed research methodology and the math models. Sensitivity analysis is the main content of the next section. Finally a short overview of sensitivity analysis is presented and the use in this research is explained.

3.4.1 Path Models

The research design section has helped to identify the initial model to be evaluated. In this section the focus will be on the different path models for the proposed research model. There are different path models because of the possible mediating effect of the Customer Service variable. Outlined below are three path models for the three different cases. The different models consider the customer service variable as full mediator, partial mediator and as a variable with no

mediating effects. In the first case customer service is no mediator. There is a direct connection between Service Reliability, Service Consistency, Service Efficiency, and Client Orientation on the one side and Business Value on the other. In addition we have a relationship between customer service and business value, but no direct or indirect relationships between the four constructs and customer service. Figure 2 shows a path model without the mediating effect.

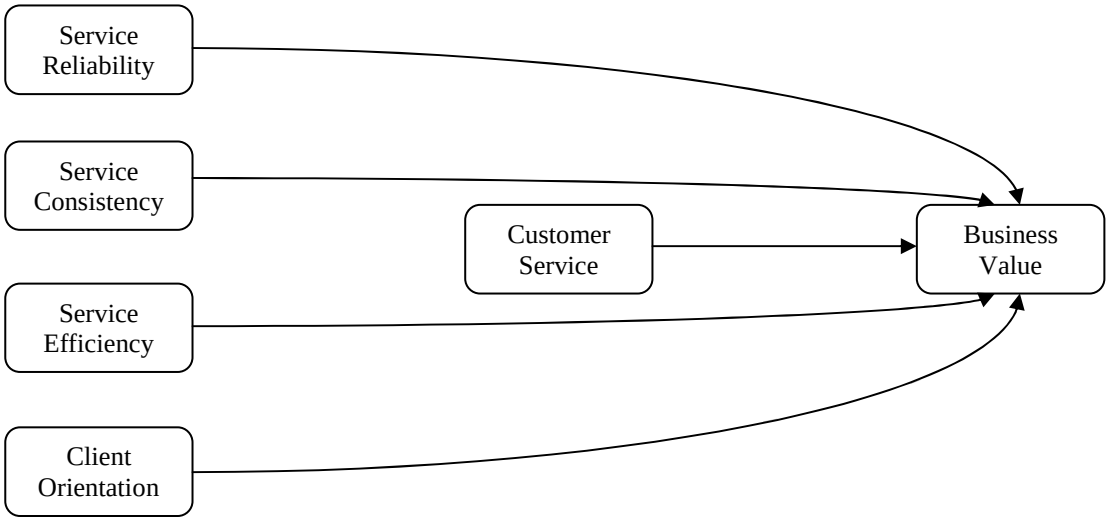


Figure 3.9: Unmediated Model

The second case illustrates a partial mediation of the Customer Service variable between the four constructs service reliability, service consistency, service efficiency, client orientation, and the business value variable. In addition to the indirect connection between the four constructs and the business value variable, these four constructs are also directly connected with the business value. In Figure3 the pathways for a partial mediation are presented.

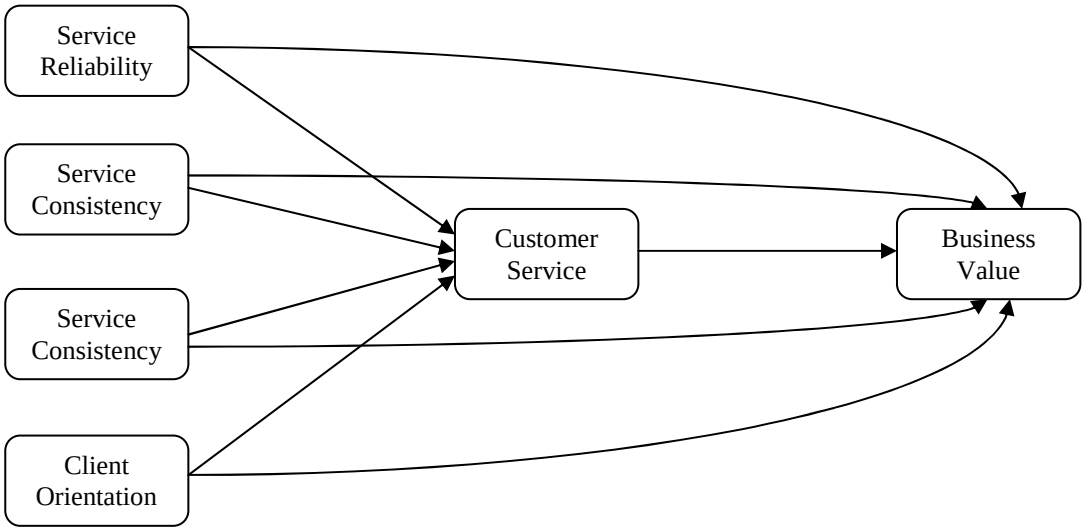


Figure 3.10: Partially Mediated Model

The last case is the full mediation of customer service. In this case there would be no direct connection between the four constructs and business value. The only connection would be through the mediator variable. Figure 4 shows the relationships of the full mediated path model.

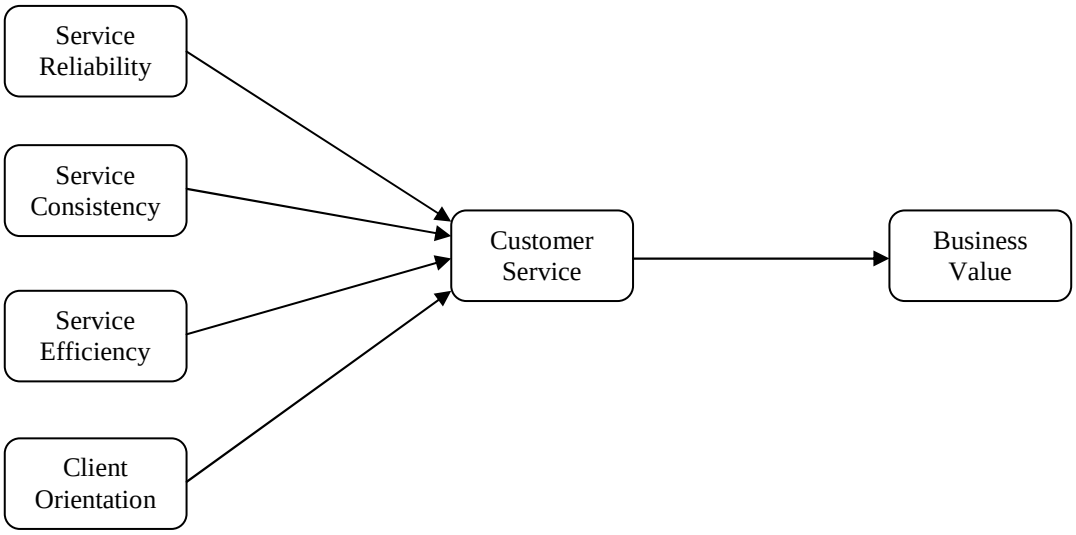


Figure 3.11: Fully Mediated Model

In the final simulation each of these pathways will be tested individually to determine the most likely model.

3.4.2 Metric Model

In this section the metric model that is used is explained in more detail. In addition estimates for each relationship are presented and justified. All constructs will have a range of values from 0 to 99. For each construct three estimates will be defined. The estimates will represent the minimum value, maximum value, and the expected value for each construct. These three estimates will later be used to perform a sensitivity analysis on the model.

Each estimated range of values will be justified by the reviewed literature in Chapter 2 and the review of previous studies in section 3.2. For some justifications additional literature is presented. The justifications will be based on empirical data where available.

According to previously reviewed literature, service reliability is very likely to increase after an organization adopts ITIL. For example, Cater-Steel et al. (2006) found in a case study research that examined five Australian companies that server faults decreased when ITIL was used. Another finding of that study was that incidents are consistently logged when a functioning ITIL framework is in place. According to the OGC, a major benefit of the use of ITIL is increased service reliability. Karimi et al. (2001) found that improved reliability of IT services is one the major contributors to improved customer service based on the use of information technology. Another study found that the number of calls made to an IT helpdesk decreased by more than 50% within the first nine month after ITIL was implemented. The same study also identified a higher satisfaction of customer with IT services due to increased service reliability and other quality measures (Potgieter et.al 2005). Hochstein et.al (2005a) found that more reliable IT service and thus a higher client and user satisfaction are a result of the use of ITIL.

The author could not find any literature that suggests that improved service reliability would not have a positive effect on customer service. Conclusively we can say that most of the literature suggests a high to very high beneficiary effect of ITIL on service reliability and of improved service reliability on customer service. Therefore the throughput of generated data for service reliability to customer service will be defined as 75 % with a minimum

throughput of 65% and a maximum throughput of 85%. The throughput from service reliability directly to business value is defined as 50% with a minimum of 40% and a maximum of 60%.

There are several studies already reviewed that suggest that the use of ITIL will improve the efficiency of IT services and that improved efficiency of IT services has a beneficiary effect on customer service. Hochstein et.al (2005a) found a higher efficiency of IT services can be realised through standardization, optimizing and automation of the processes. Another study identified seamless end-to-end service as an advantage of the use of ITIL (Cater-Steel et.al 2006). Karimi et.al (2001) found that reaction times of IT services decrease when a functioning IT service management solution is implemented.

Conclusively it can be claimed that most of the literature suggests a high to very high beneficiary effect of ITIL on service efficiency and of improved service efficiency on customer service. Therefore the throughput of generated data for service efficiency will be similar to the throughput of service reliability to customer service and therefore be defined as 75 % with a minimum throughput of 65% and a maximum throughput of 85%. The throughput from service efficiency directly to business value is defined as 60% with a minimum of 50% and a maximum of 70%.

Consistency of services is another contributor to improved customer service. According to Hochstein et.al (2005a), the consistency of IT service increases when ITIL is used. They found that documentation and supervision of the services guarantees higher transparency and thus higher consistency. Potgieter et.al (2005) also found that services are more consistent after ITIL is adopted. In addition they found that this has a beneficiary effect on customer service.

Conclusively the literature suggests a medium to high beneficiary effect of ITIL on service consistency and of improved service consistency on customer service. Therefore the throughput of generated data for service consistency will be defined as 60 % with a minimum throughput of 50% and a maximum throughput of 70%. The throughput from service consistency to business value is defined as 30% with a minimum of 20% and a maximum of 40%.

There are a number of reasons why higher client orientation of IT service will have a positive impact on customer service. Hochstein et.al (2005b) found in

a case-study based research that all investigated companies achieved a higher client and service orientation and that this was one of the major advantages of ITIL implementations. Potgieter et.al (2005) also found higher client orientation as one of the major contributor of ITIL to improved customer service.

Conclusively the reviewed literature suggests a very high beneficiary effect of ITIL on client orientation and of higher client orientation on customer service. Therefore the throughput of generated data for client orientation will be defined as 85 % with a minimum throughput of 75% and a maximum throughput of 95%. The throughput from client orientation directly to business value is defined as 30% with a minimum of 20% and a maximum of 40%. The direct throughput to business value is assumed to be likely at best. Literature does only suggest an impact of higher client orientation on customer service, but not directly on business value.

Improved customer service generates additional value to the business through a number of channels. One of the studies reviewed earlier found that "customer satisfaction and operational performance improve as the activities in the ITIL framework increases" (Potgieter et al. 2005, p. 166). Conclusively most of the literature suggests a high to very high beneficiary effect of improved customer service on business value. Therefore the throughput of generated data for service reliability will be defined as 75 percent with a minimum throughput of 65 percent and a maximum throughput of 85 percent.

Table1 below shows an overview of the estimates for each relationship. Only the medium estimates are presented for each relationship. All estimates are to be seen as percentage of throughput from one construct to the next.

Table 3.1: Overview of Estimates

	Service Reliability	Service Consistency	Service Efficiency	Client Orientation	Customer Service
Customer Service	75	60	75	85	
Business Value	50	30	60	30	75

3.4.3 Constraints

This chapter will discuss the constraints to the models that will be tested in this thesis. These constraints are mainly due to necessary adjustments to the path models in order to test the different states that the customer service variable can have within the initial research model.

One constraint of the proposed methodology is the requirement of the simulation approach to define a model that will be tested prior to the execution of the simulation. Therefore the four possible benefits of ITIL, service reliability, service consistency, service efficiency, and client orientation, had to be defined based on the findings of currently available research concerning ITIL. The problem is that the benefits that ITIL might be able to deliver are far from being fully researched. Considering the lack of available knowledge in this area, the author might have based his decisions regarding the most likely benefits on an incomplete body of knowledge.

On the numerical part of the models each created value has to be between 0 and 99. For each relationship a range of values is created and only the randomly created numbers that fit into this range are put through to the next variable. In addition the upper limit for the throughput of the created values will be set at three different levels, representing the estimated value, the minimum value, and the maximum value. The three different levels are necessary to perform sensitivity analysis on the simulation.

The three different path ways require certain constraints each. In the unmediated model the four primary constructs will be forced to one single relation each, representing the relationship to the business value variable. In the fully mediated model the relationships are restricted respectively, meaning the four primary constructs are forced to build a relationship with the customer service variable and are not permitted to have a relationship with the business value variable. In the partial mediated model each of the four constructs is forced to have a relationship with customer service and business value. In addition the number of possible combinations, regarding the minimum value, maximum value and expected value of the different constructs, in each model is limited. The next section will contain more information to the limits of the combinations.

3.4.4 Sensitivity Analysis

The chapter presents information to the sensitivity analysis used in the simulation process of this research project. Sensitivity Analysis can be used to address the uncertainty in the mathematical models, to simplify models, to investigate the robustness of models, or simply as an element of quality assurance. It can also be used to investigate how the variation in the output of a simulation can be apportioned to the sources of variation in the created input (Saltelli 2002).

In this case sensitivity analysis will be used to address the uncertainty of the model. In section 3.4.3 estimates for the constructs were developed based on the reviewed literature. Each of these estimates has three different values: expected value, minimum value, and maximum value. To determine the sensitivity of the proposed pathways each pathway will be tested with the different values and the outcomes will be compared to determine the reaction of the models to a change in the range of values. The four primary constructs will always have same setting for the range of values, because they are independent from each other.

3.5 FORECASTED OUTCOMES

This section contains information to the operationalising of the research and the forecasted outcomes. The operationalising section contains information to the realization of the simulation. The proposed instrumental processes are outlined above provide a qualified certainty that an answers or multiple answers to the research question can be found. The forecasted outcomes are the expectations of the author holds based on the foregone discussions, the theory, and the expected range of results from the simulation. The final sub section discusses the limitations of this research approach and methodology.

3.5.1 Operationalising the Research

The steps undertaken to execute the research are practical and involve the software and hardware, and the techniques involved in executing the simulation. The simulation will be run on a personal computer with a 2.4 GH dual-core processor and 4GB of ram.

The simulation will be executed using one MS Excel spreadsheet for each of the proposed path ways. The data for each of the constructs will be created using Monte Carlo simulation. A number of publications on how to realise a simulation approach using the Monte Carlo method in MS Excel were reviewed (e.g. Gedam et al. 2000, Hardy 2002, Keeling et al. 2004). Especially Gedam et al. (2000) provides useful information to the execution of Monte Carlo simulations in Excel.

The formula for creating random numbers within certain restriction for each of the columns is RAND * (max-min) + min with max being the maximum value and min being the minimum value for each of the constructs. In our case the maximum value is 99 and the minimum value 0. So the formula used to create the data sample is RAND * (99 – 0) + 0. The so created values are then processed through an algorithm that identifies the number of elements that will be put through to the customer service variable. This algorithm is based on the number identified in the previous two chapters. For the element that was put through a new random number is then created using the formula stated above. The number received through that random generation are then processed through another algorithm that contains the definitions for the throughput from customer service to business value. In the partial mediated model additional algorithms are formulated for the direct connections of the four initial constructs and the business value variable. In the model where customer service is not mediating the relationship between the initial constructs and business value only the direct relationships will be considered.

The process defined above equals one simulation run. Literature does not suggest an ideal number of runs, because every simulation is different. The only suggestion that can be found frequently is the suggestion to take a large enough number of runs. After investigating previous researches that used simulation methodology the author decided to start with a pilot run and 1000 repetitions. The final simulation will then be run with 10,000 repetitions to ensure accuracy of the results. In addition one randomly chosen model will be run 100,000 times to ensure stability on a larger scale.

To execute the simulation a Macro was developed that automates the repetition process and saves the results of each run. The Macro was developed using the record function of Excel. Necessary additions were implemented after the recording. The source code is attached in the Appendices.

3.5.2 Theoretical Expectations

This chapter presents the expected outcomes of the research. All expectations are based exclusively on the reviewed literature and the knowledge of the author. The proposed hypotheses will be evaluated with the expected outcomes to determine the capability of the chosen methodology to deliver answers to the research questions.

Starting with the hypotheses the sequence will work through to the main research question. The five hypotheses are re-stated below:

> H1: The use of ITIL will improve customer service through higher reliability of IT services.
>
> H2: The use of ITIL will improve customer service through higher consistency of IT services.
>
> H3: The use of ITIL will improve customer service through higher efficiency of IT services.
>
> H4: The use of ITIL will improve customer service through a higher client orientation of IT departments and the services that they provide.
>
> H5: The use of ITIL will create value to the business through improved customer service.

Each of these hypotheses will be tested against the results of simulation. Therefore an extensive statistical analysis of the factors that contributed to the results will be conducted. The results of that analysis will identify the contribution that each of the four constructs, service reliability, service consistency, service efficiency, and client orientation, has to the improvement of customer service. The author is confident that the positive relationships between service reliability, service efficiency, and client orientation on the one hand and customer service on the other, are very likely to be proved. It is also likely that a positive relationship between service consistency and customer service can be established even though the reviewed literature did not mention consistency of service as one of the major advantages of the use of ITIL. It is almost certain that improved customer service will prove to be a contributor to business success and therefore a creator of additional business value.

In addition the author believes that the model representing customer service as full mediator between the four constructs and business value is the most likely scenario. This will be shown by comparing the outcomes of the simulation for the different path models.

The next step is a prediction of the outcome of the research in the context of the main research question. The main research question is stated below:

> Q1: What are the perceived benefits for customer service of the use of the IT Infrastructure Library?

To answer the main research question it will be necessary to evaluate the individual results for each construct and its relationships with customer service and business value. The result of that analysis will identify the perceived benefits for customer service of the use of ITIL. The author expects that it is very likely that service reliability, service efficiency, and client orientation will be evaluated as benefits of ITIL use, because the reviewed literature strongly suggests a beneficiary effect of these three factors. It is also likely that service consistency has a beneficiary effect on customer service, but compared to the other three factors service consistency is not mentioned so often.

3.5.3 Limitations

This section will discuss the limitations and constraints that come with a simulation approach based on Monte Carlo method. General limitations of simulation and specific limitations of this research will be introduced.

One of the most critical points in simulation based research is the development of the estimates for the observed variables and constructs. Conrad (2003) notes that estimates are mostly based on the knowledge of experts and that therefore estimates are merely representations of the possible values. In this research the estimates are based almost exclusively on the qualitative findings of other researchers due to the fact that there is a lack of reliable quantitative data concerned with benefits of the use of ITIL. Another limitation of the simulation approach is the fact that the model is just a simplified representation of the real-life reference system (Klingstam et al. 1999).

In this study the simplification is the limitations of the created constructs. Even though there might be other possible benefits for customer service of ITIL use, the published literature suggests that the selected items are the most likely contributors.

A limitation of the Monte-Carlo approach is the use of pseudo-random numbers. These numbers cause the results of the simulation to be slightly unreliable. The unreliability will decrease when the number of trial is increased. Thus a large number of trials will be performed to present a solution to that problem.

3.6 CONCLUSION

In this chapter the research framework and the research model proposed for use in this research were developed and defined. Five similar studies were reviewed and the results of these studies and the literature reviewed in Chapter 2 formed the basis for the research design.

The design of the initial research model included 6 variables. In addition an overview of the theory behind simulation based on Monte Carlo method was presented. Three different pathways for the initial research model were introduced and explained. These pathway models considered the different roles of the customer service variable. The estimates for the math model were presented and justified and the constraints were outlined. Next sensitivity analysis was introduced and its use in this work explained. The operationalising of the research was also explained. The simulation will be run using an Excel spreadsheet. In addition a forecasted outcome of the simulation and information on how the author intends to evaluate the hypotheses was presented. The last chapter mentioned possible limitations of simulation in general and limitations of the specific research methodology used in this thesis.

The next chapter will present the findings of the simulation. Therefore the result of each path model will be presented separately and the most likely pathway will be determined. The focus will be on the distributions of the combined results of the simulation. In addition a section that contains the findings regarding sensitivity analysis will be presented. Furthermore, a section comparing the distribution for different numbers of runs will be presented to analyse the

behaviour of the system with different repetitions. The next chapter will conclude by presenting a summary of the findings.

Chapter - 4 Findings of the Research

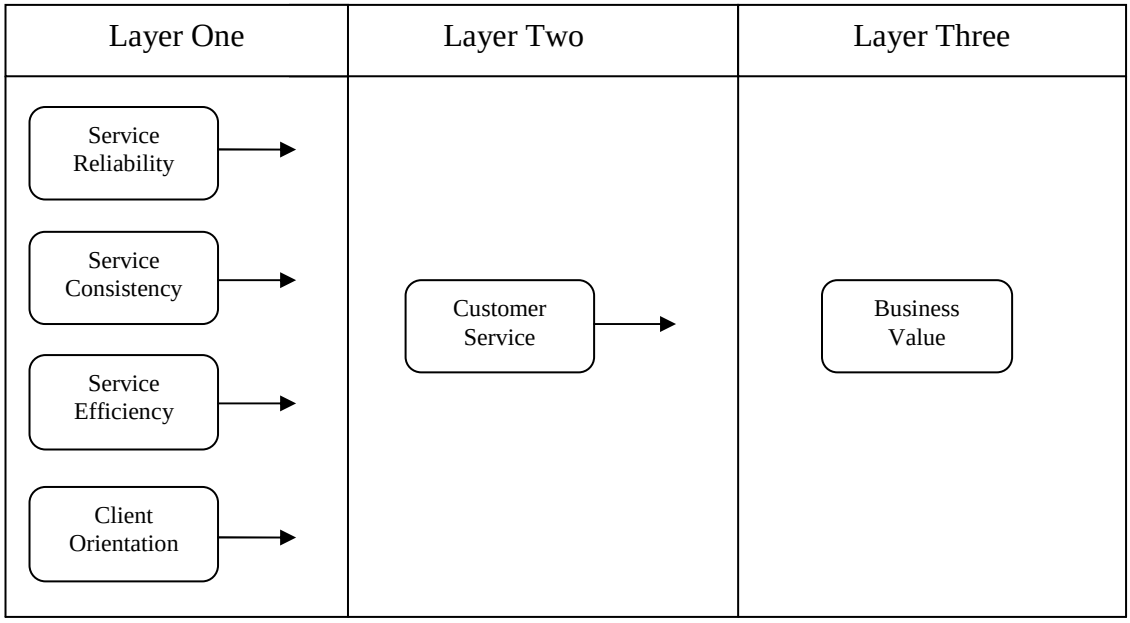
4.0 INTRODUCTION

In this chapter the findings of the simulation are presented. The structure is split into sections for each pathway model, the full mediated model, the unmediated model, and the partial mediated model. Each section will provide a detailed overview of the simulation results and the results of the sensitivity analysis for each model. The following chapter has the discussion and interpretation of the findings.

A total number of 8000 values were created for each simulation run of the partially mediated model and the fully mediated model, 2000 for each of the four constructs. The unmediated model contained a total number of 10000 created values, 2000 values for each of the constructs.

In order to simplify the presentation of the results some new terms for the constructs have to be defined. The four constructs, service reliability, service consistency, service efficiency and client orientation, will be called “layer one”. These four constructs behave in the same way and are independent from each other. The customer service variable will be called “layer two”. Respectively business value is called “layer three”. Figure 4.1 presents a graphical summary of these new terms.

Table 4.1: Definition of Layers



As mentioned in Section 3.4.2, three different estimates for the throughput of the different variables were created in order to perform sensitivity analysis on the output of the simulation. The medium value was derived from literature and is defined to be the most likely estimate for the specific model. In order to simplify the reporting of the results for the sensitivity analysis, the different estimates for each construct will be called “low”, “medium”, and “high”. “Low” is representing the defined minimum throughput percentage, while “high” is representing the defined maximum throughput percentage. “Medium” is representing the most likely estimate for each of the relationships.

4.1 PROBLEMS ENCOUNTERED DURING SIMULATION

This section reports the problems encountered while executing the simulation. The problems will be split into technical problems and problems regarding the modelling. An overview of the problems and the solutions is presented.

The technical side of the simulation encountered some initial problems. One of the major problems was the runtime for each of the repetitions of the different models. Initially it was planned to create 50,000 random values for each construct with the purpose to increase the accuracy of the simulation results. In the partially mediated model that means a total number of 200,000 created values. Each of these values has to be processed through two different algorithms which added up to 400,000 calculations. The total number of calculation had to be repeated 10,000 times to simulate the defined number of runs. The result was that each of the 21 tested combinations would have ended up with 4,000,000,000 calculations. The first model that was tested took over 2 hours to test a single combination. The consequence of that was that the author went back to research the methodologies of other studies that used Monte Carlo simulation. The result of that review was a reduction of the created values for each construct to 2000. None of the reviewed previous studies used more than 2000 created values for each construct in their simulation. The general literature regarding simulation methodology does not suggest any limits to the number of created values.

Difficulties with the modelling were only encountered in the partially mediated model. The problem in that model was the distinction between the number of values that get put through from layer one to layer two and those that

get put through from layer one to layer three. To keep the total number of created values stable the throughput for each of the relationships was limited to 50% of the total number of created values.

4.2 FULL MEDIATION MODEL

This section presents the results of the simulation for the fully mediated model. Therefore a table containing the distribution of the outcomes of the 10.000 runs is presented. In addition a histogram is presented to show the results of the simulation with the most likely estimates.

This model was run with nine different settings. These settings represented each possible combination of the different estimates in layer one and layer two. The nine runs were necessary to perform sensitivity analysis on the results of the simulation for the fully mediated model. The according diagrams are presented in the sensitivity analysis section 4.5.

Figure 4.1 shows a diagram of the distribution of the simulation results when all estimates are set on “medium”. It can be seen that the distribution has the shape of a normal distribution.

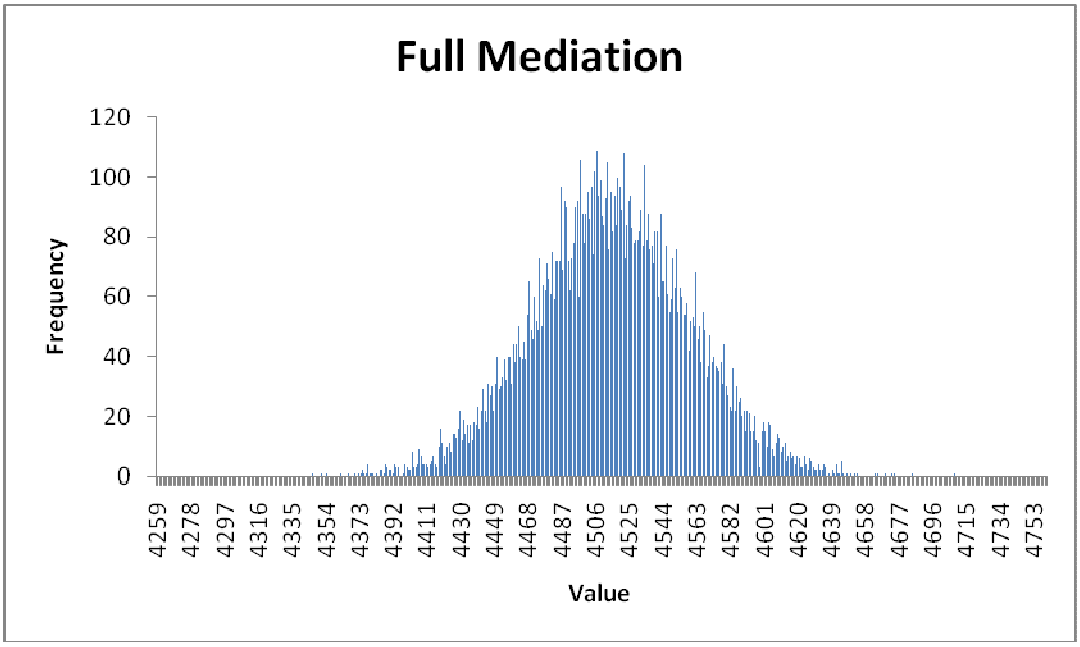


Figure 4.1: Distribution of the Fully Mediated Model

The mean of this distribution is at 4515 points which means that 4515 of the values of the initially created 8000 input values were put through the implemented

algorithms. The total throughput percentage for the input values is 56.44%. The minimum throughput encountered during the 10,000 runs is 4347 and the maximum throughput is 4709. The range of output values is therefore 362 values or 4.53% of the total range of input values.

4.3 UNMEDIATED MODEL

This section presents the results of the simulation for the unmediated model. Therefore a table containing the distribution of the outcomes of the 10.000 runs is presented. In addition a histogram is presented to show the results of the simulation with the most likely estimates.

This model was run with three different settings. These settings represented each possible combination of the different estimates in layer one and layer two. Since this model does not allow any relationship between the layer one construct and the layer two construct, it is assumed that all constructs are independent from each other. Therefore to total number of combinations compared to the fully mediated model decreased from nine to three. The three runs were necessary to perform sensitivity analysis on the results of the simulation for the unmediated model.

Figure 4.2 shows the results for the unmediated model when the estimates were set as “medium”. The mean of this distribution is at 4950 out of 10000 input values. The percentage of throughput is 49.50%. The minimum throughput encountered during the 10,000 simulation runs was 4769 and the maximum throughput was 5118. The range of values for the output is 349 or 3.49% of the total input of 10000 values.

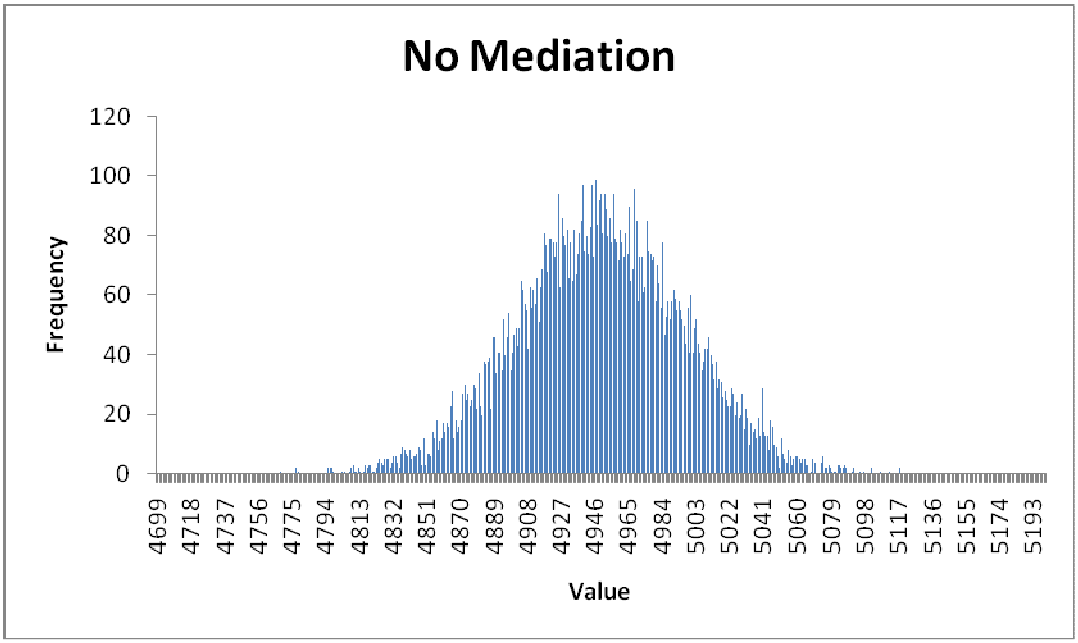


Figure 4.2: Distribution of the Unmediated Model

4.4 PARTIAL MEDIATION MODEL

This section presents the results of the simulation for the partially mediated model. Therefore a table containing the distribution of the outcomes of the 10.000 runs is presented. In addition a histogram is presented to show the results of the simulation with the most likely estimates.

This model was run with nine different settings. These settings represented each possible combination of the different estimates in layer one and layer two. The nine runs were necessary to perform sensitivity analysis on the results of the simulation for the fully mediated model. In addition the total number of created values from layer one that contribute to the other layers was split equally between layer two and layer three. The total number of created values was held stable at 8000.

Figure 4.3 shows the result of the simulation for the partially mediated model when all estimates were set to “medium”.

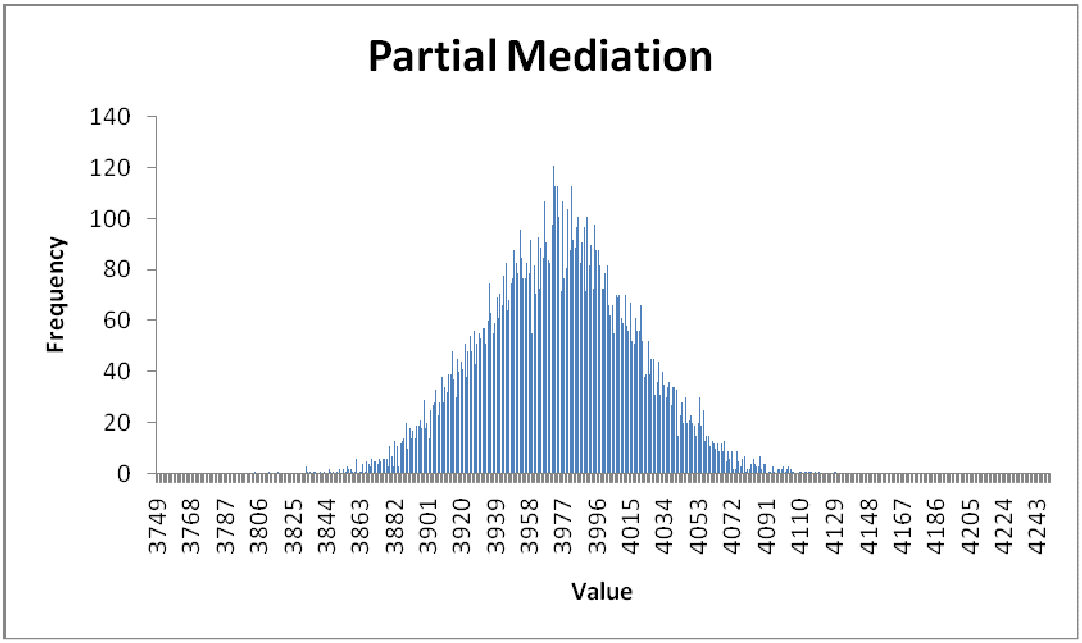


Figure 4.3: Distribution of the Partially Mediated Model

The mean of this distribution is at 3975 out of 8000 created values. The percentage of throughput for the generated input is 49.68%. The minimum value encountered during the 10,000 runs was 3804 and the maximum was 4130. The range of output values is 326 or 4.08% of the generated input.

4.5 DATA ANALYSIS INCLUDING SENSITIVITY ANALYSIS

This section presents the observations made regarding the analysis of the simulation results. Therefore three subsections are present that focus on the distribution of the simulation results, the means of the distributions and on the total number of runs of the simulation.

The first subsection will present diagrams for the distributions of the simulation results of each of the 21 different settings that were observed. These diagrams will be regarded separately for each of the three different path way models that were proposed in the research methodology chapter.

The second subsection will focus on analysing the total value of the means and the change in means for each of the settings. Therefore diagrams representing the total value of the means are presented. In addition tables represent the change in means for every possible change of settings within the models. The changes follow a certain pattern that is identified in this subsection.

The third subsection is concerned with the increase in accuracy of the results of the simulation in regard to the total number of repetitions. Therefore three diagrams representing the distribution of one randomly chosen specific setting in one model are presented. The difference in the diagrams will be the total number of runs that delivered the source data. Therefore the simulation was run 1,000, 10,000, and 100,000 times.

4.5.1 Distributions of the Simulation Results

The distributions for the unmediated model with the estimates set to “high”, “medium” and “low” are shown in the next three figures. It can clearly be seen that the shapes of the distributions in all three models is very similar.

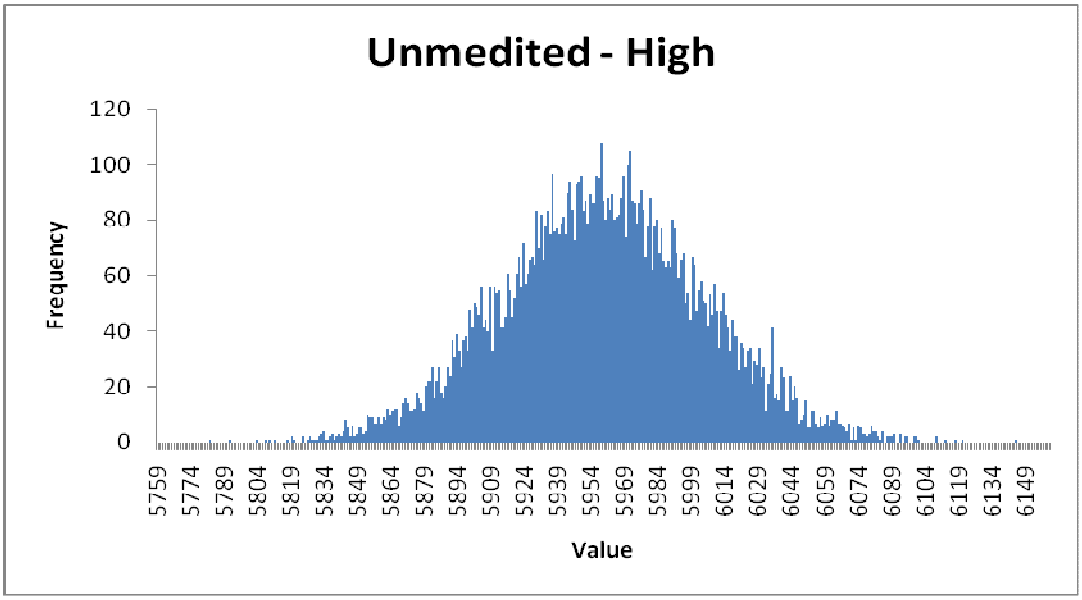


Figure 4.4: Unmediated Model with Estimates on High

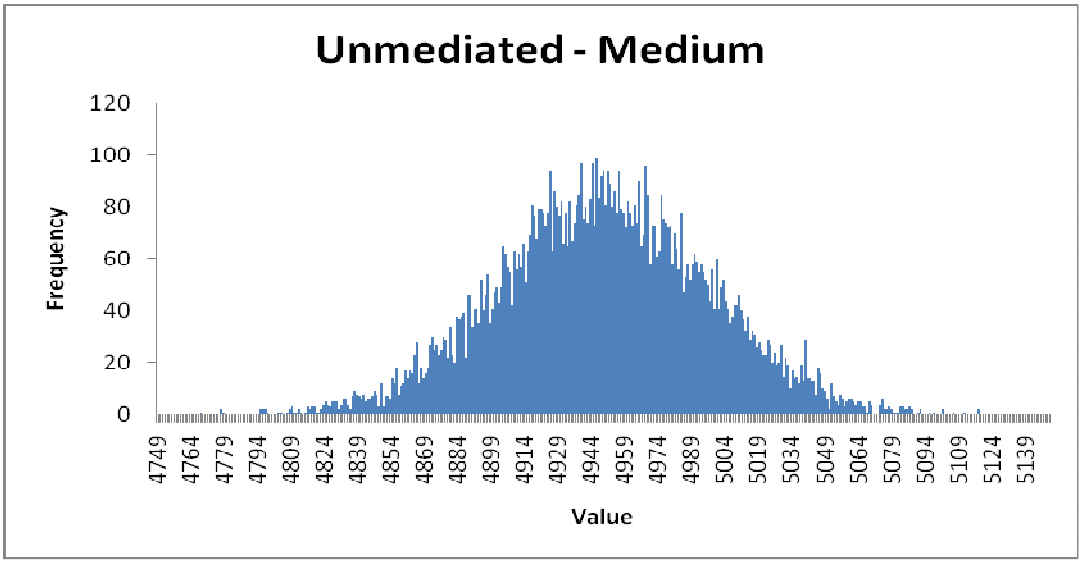


Figure 4.5: Unmediated Model with Estimates on Medium

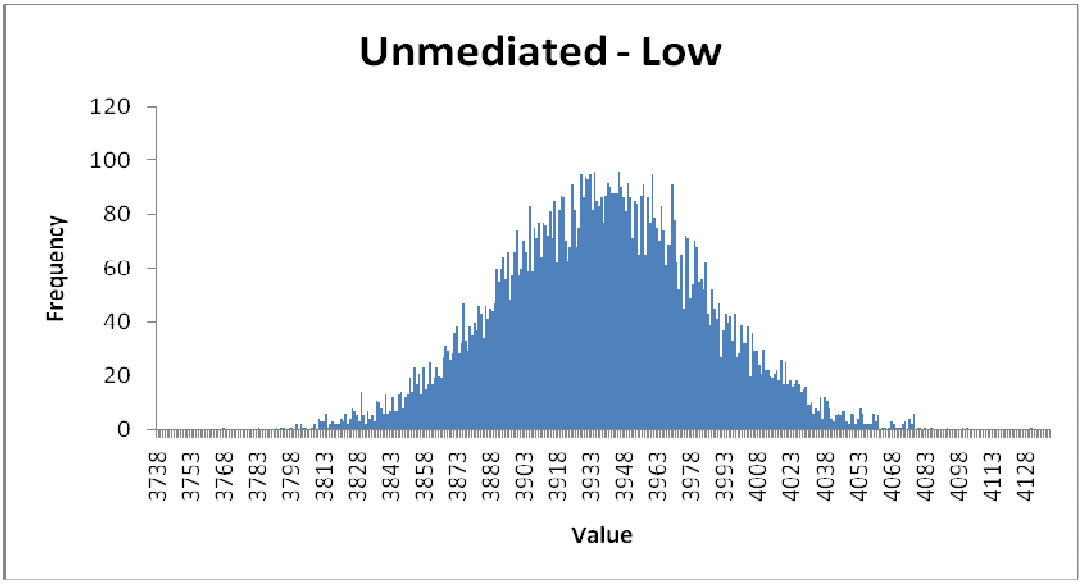


Figure 4.6: Unmediated Model with Estimates on Low

Figures 4.4, 4.5, and 4.6 represent the unmediated model with the first layer and the second layer set to the three different estimates. It can be seen that the shape of the distribution does not change by a change in the estimates. In addition the mean increases by 1011 points when the estimates are changed from “low” to medium and by 1010 points when the estimates are changed from “medium” to “high”.

The next set of diagrams shows the distributions for the different settings of the estimates in the partially mediated model. The titles of the diagrams show the settings for that specific diagram. The first word represents the setting of the

estimates for layer one and the second word represents the layer two setting. The total number of diagrams that are presented for the partial mediation model is nine. The diagrams will be presented in groups of three; representing the three different estimates in layer two for one specific estimate in layer one.

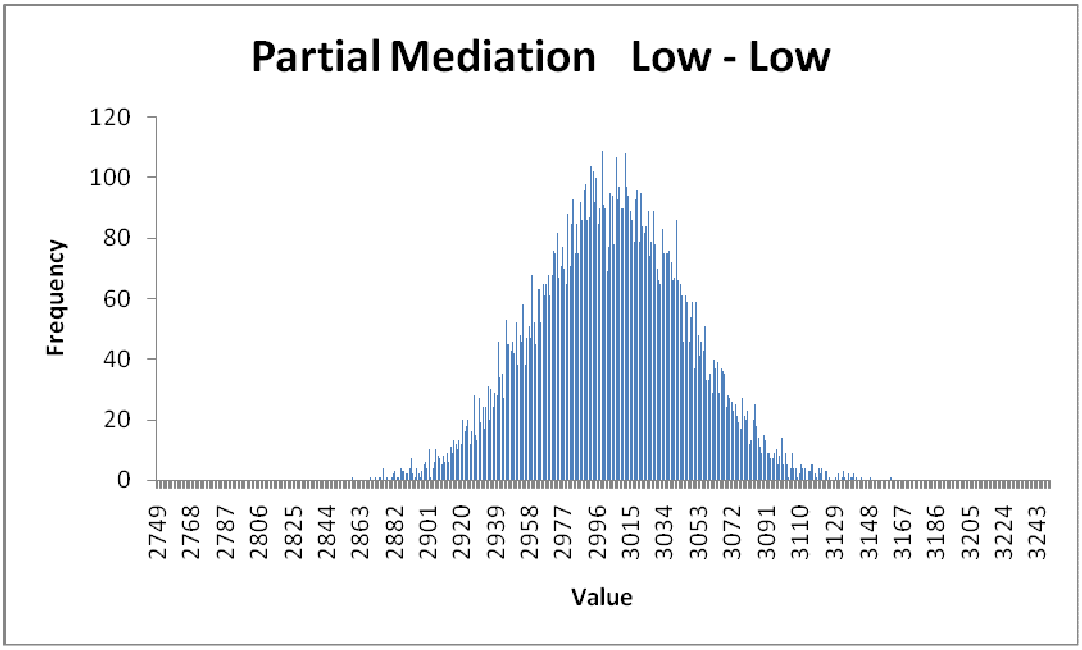


Figure 4.7: Partial Mediation Model with Estimates on Low - Low

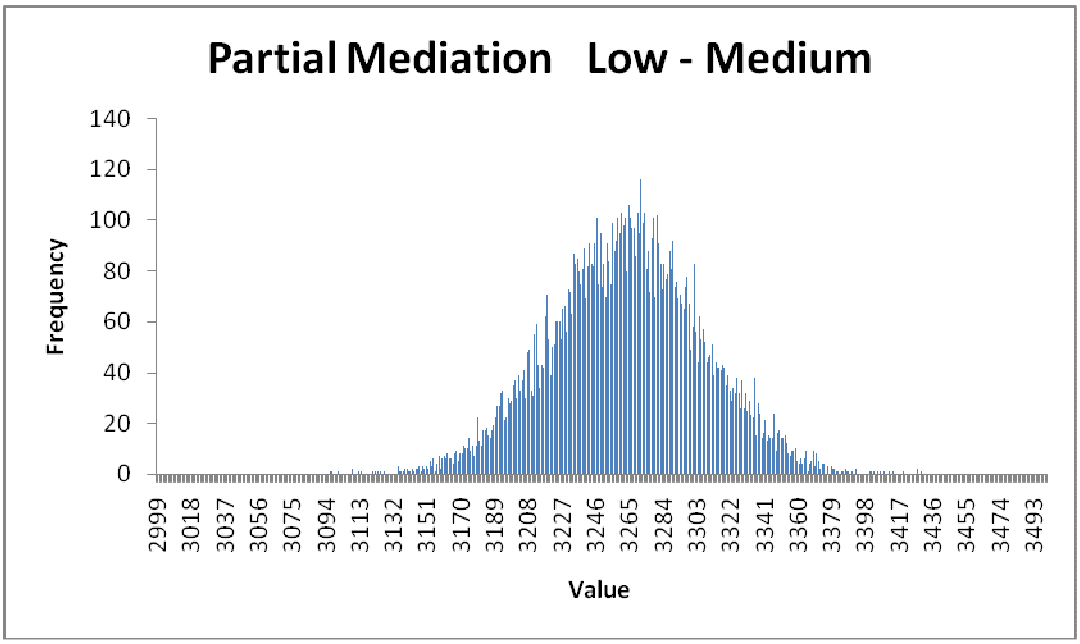


Figure 4.8: Partial Mediation Model with Estimates on Low - Medium

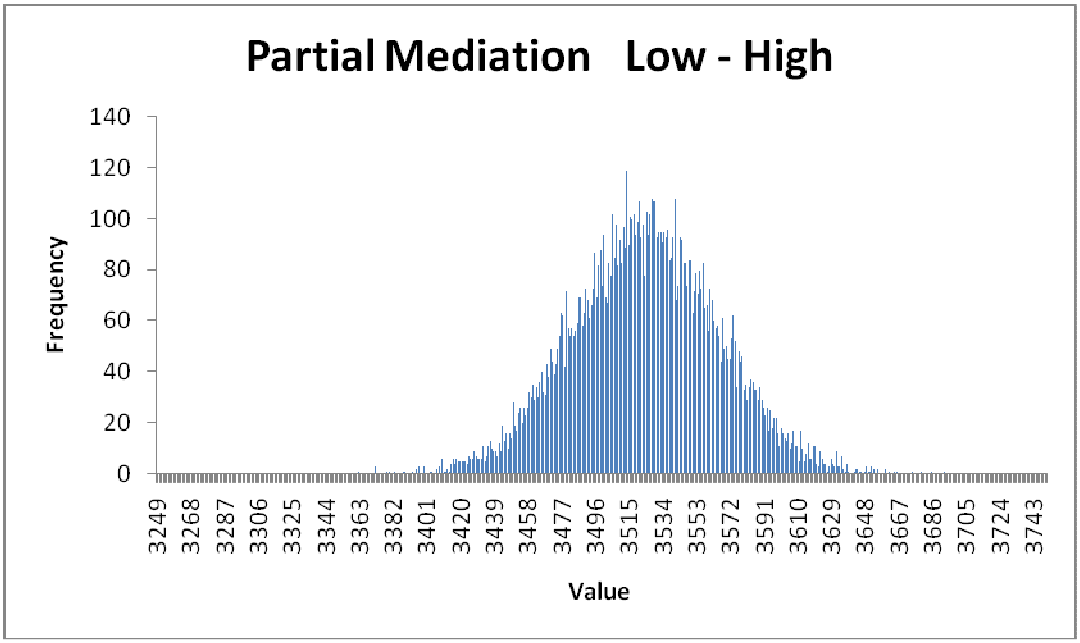


Figure 4.9: Partial Mediation Model with Estimates on Low - High

Figures 4.7, 4.8, and 4.9 represent the partially mediated model with the first layer set to "low" and the second layer set to the three different estimates it can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 260 points when the estimates in layer two are increased.

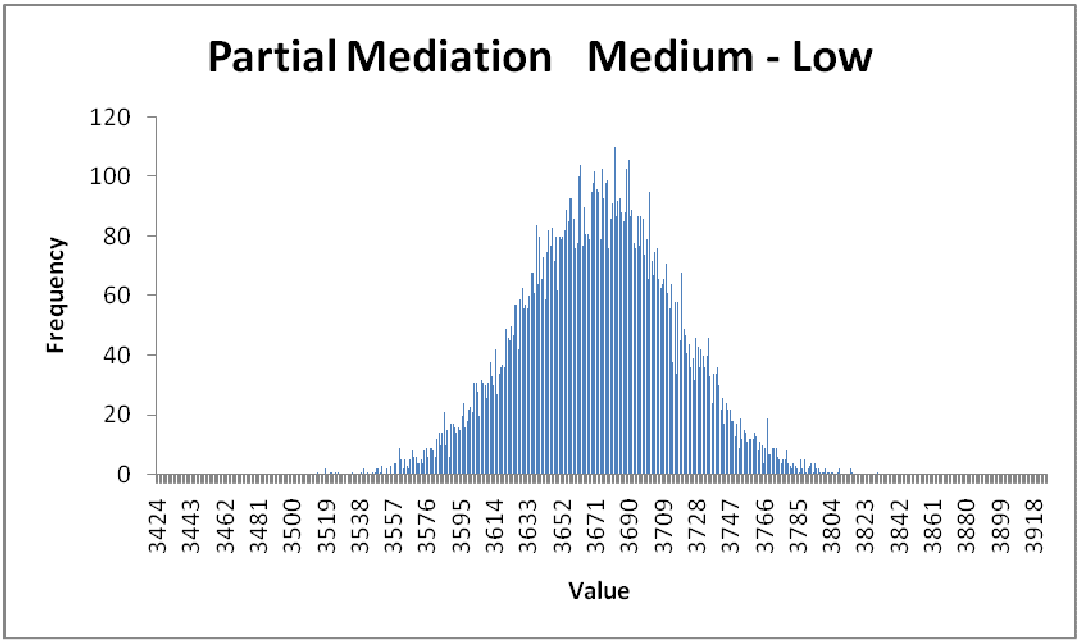


Figure 4.10: Partial Mediation Model with Estimates on Medium - Low

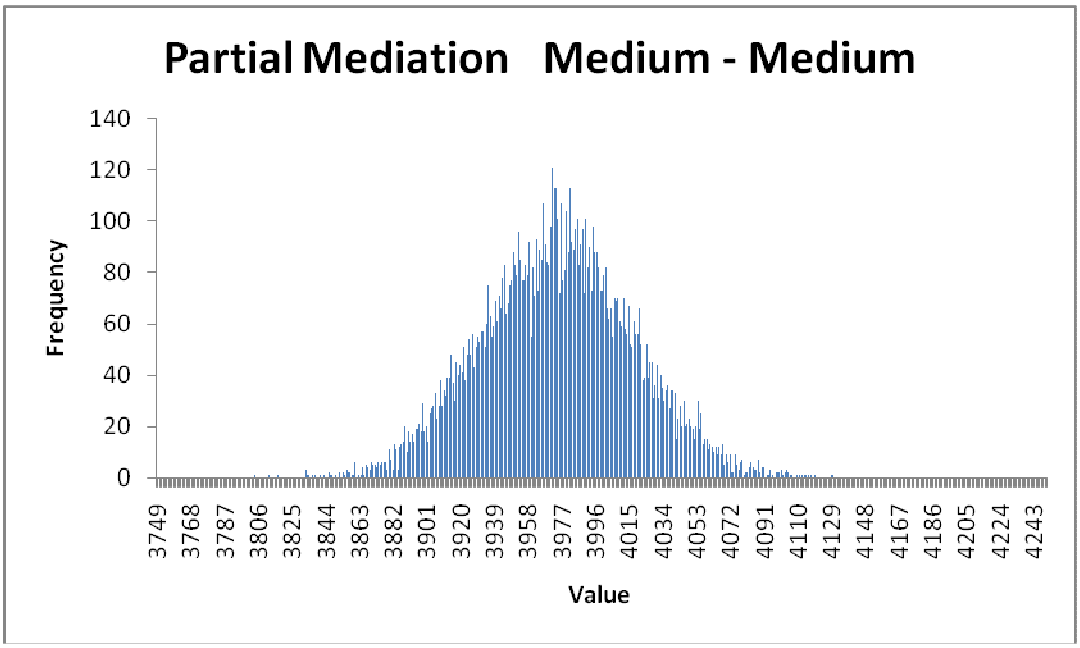


Figure 4.11: Partial Mediation Model with Estimates on Medium - Medium

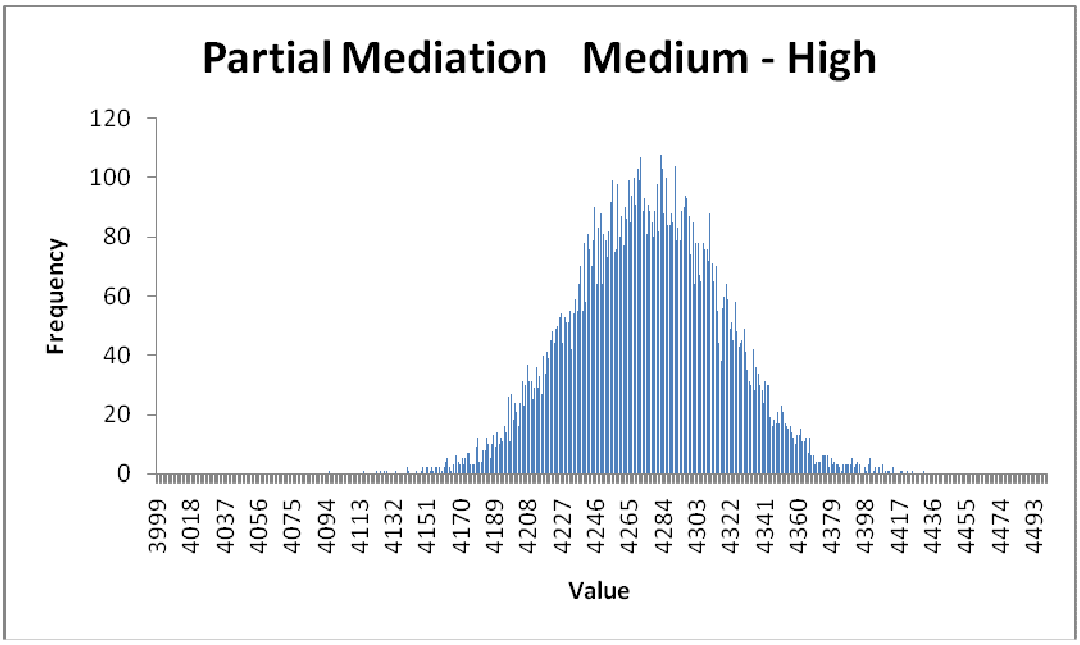


Figure 4.12: Partial Mediation Model with Estimates on Medium - High

Figures 4.10, 4.11, and 4.12 represent the partially mediated model with the first layer set to “medium” and the second layer set to the three different estimates “low”, “medium”, and “high”. It can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 302 points when the estimates in layer two are changed from “low” to medium and by 301 points when the estimates are changed from “medium” to “high”.

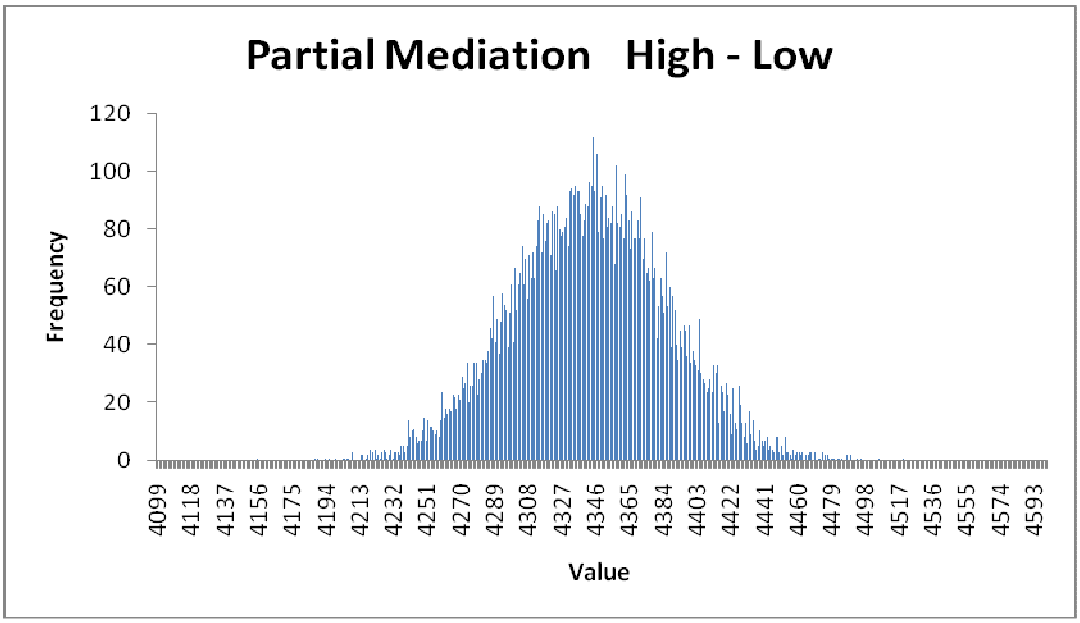


Figure 4.13: Partial Mediation Model with Estimates on High - Low

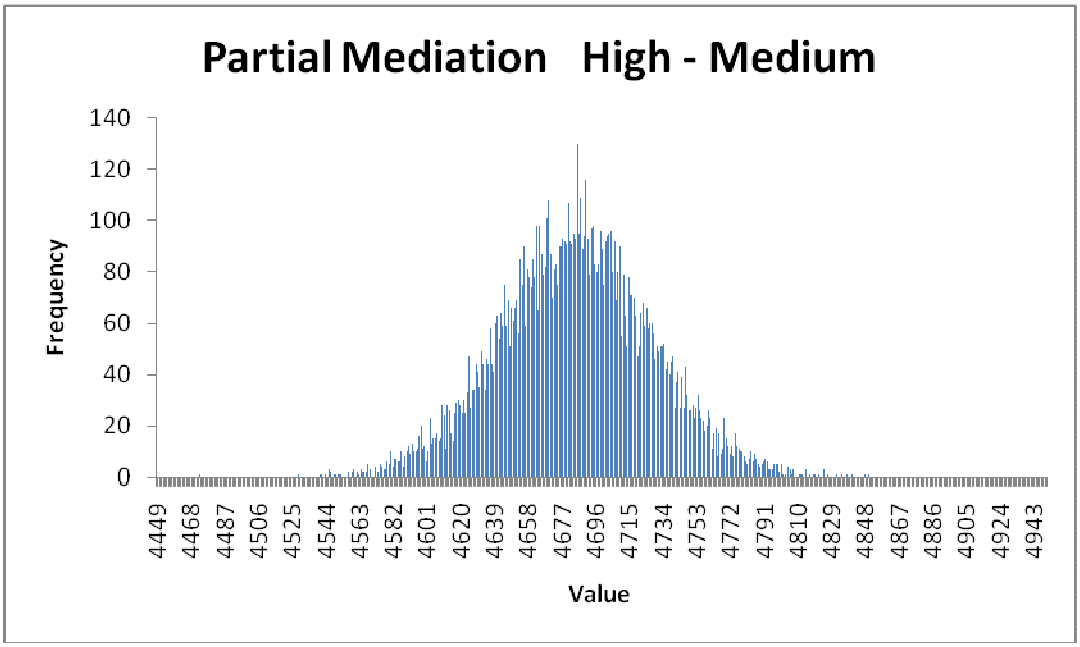


Figure 4.14: Partial Mediation Model with Estimates on High - Medium

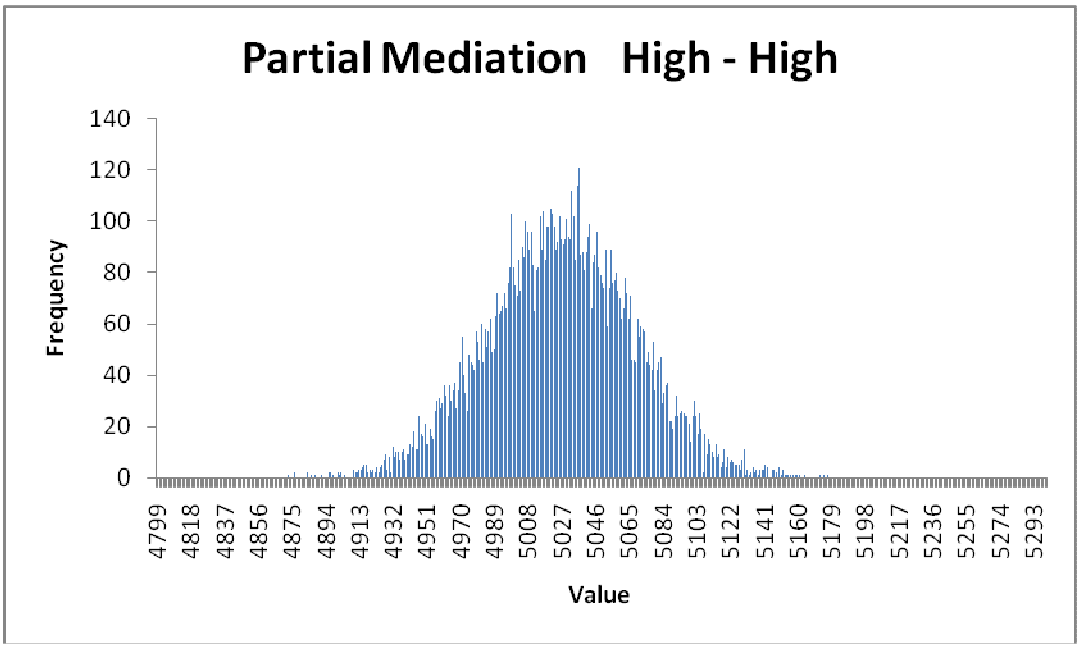


Figure 4.15: Partial Mediation Model with Estimates on High - High

Figures 4.13, 4.14, and 4.15 represent the partially mediated model with the first layer set to “high” and the second layer set to the three different estimates “low”, “medium”, and “high”. It can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 342 points when the estimates in layer two are increased.

Figures 4.16, 4.17, 4.18, 4.19, 4.20, 4.21, 4.22, 4.23, and 4.24 show the distributions for the different settings of the estimates in the fully mediated model. The titles of the diagrams show the settings for that specific diagram. The first word represents the setting of the estimates for layer one and the second word represents the layer two setting. The total number of diagrams that are presented for the full mediation model is nine. The diagrams will be presented in groups of three; representing the three different estimates in layer two for one specific estimate in layer one.

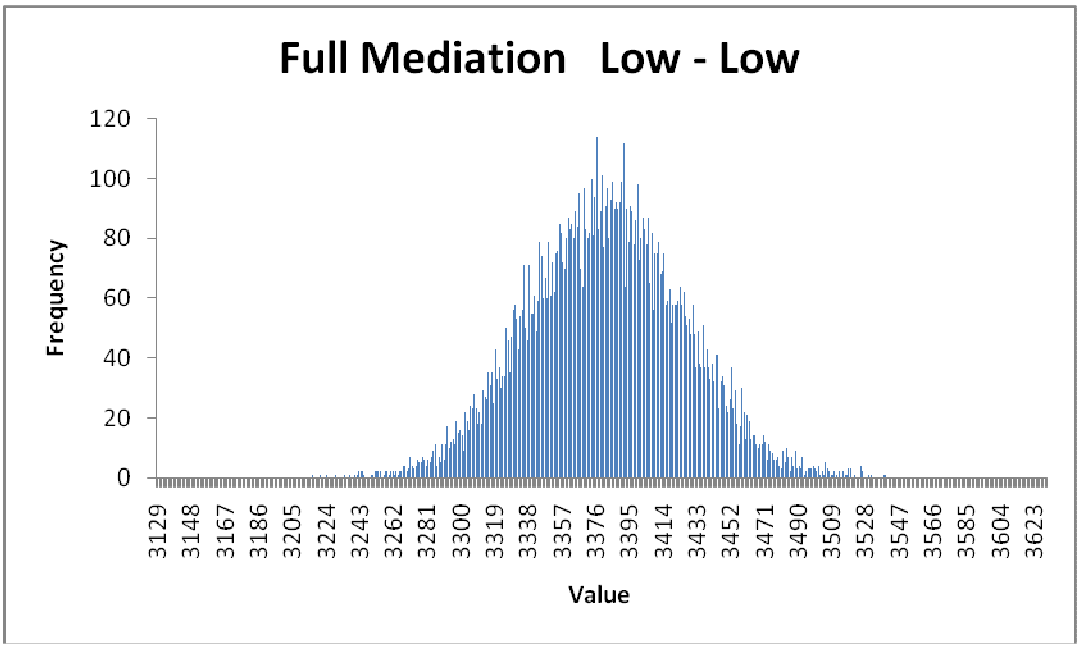


Figure 4.16: Full Mediation Model with Estimates on Low -Low

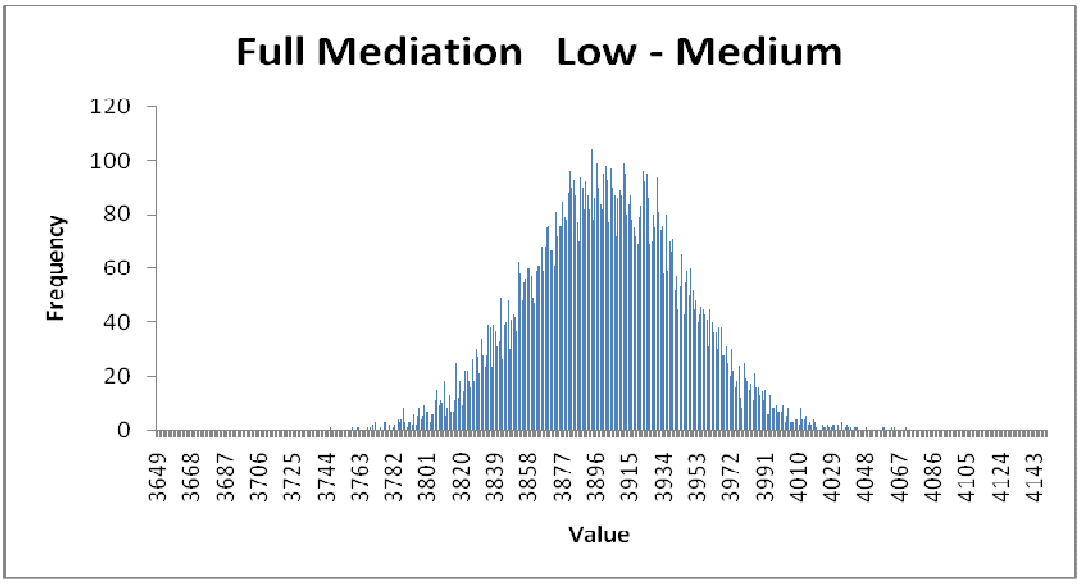


Figure 4.17: Full Mediation Model with Estimates on Low - Medium

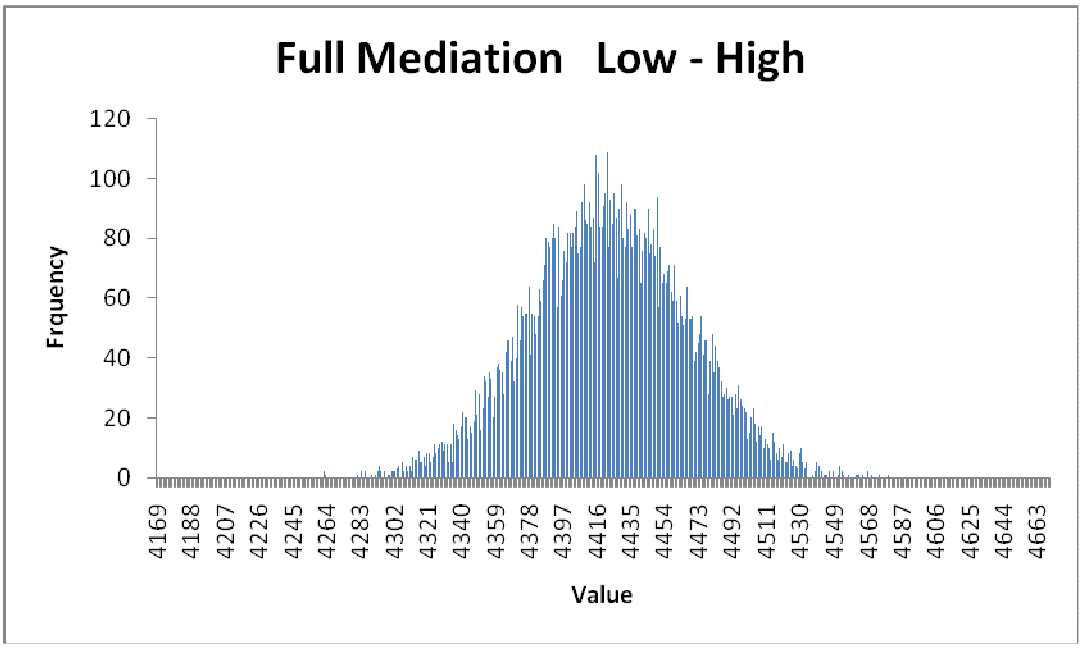


Figure 4.18: Full Mediation Model with Estimates on Low - High

Figures 4.16, 4.17, and 4.18 represent the fully mediated model with the first layer set to "low" and the second layer set to the three different estimates "low", "medium", and "high". It can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 520 points when the estimates in layer two are increased.

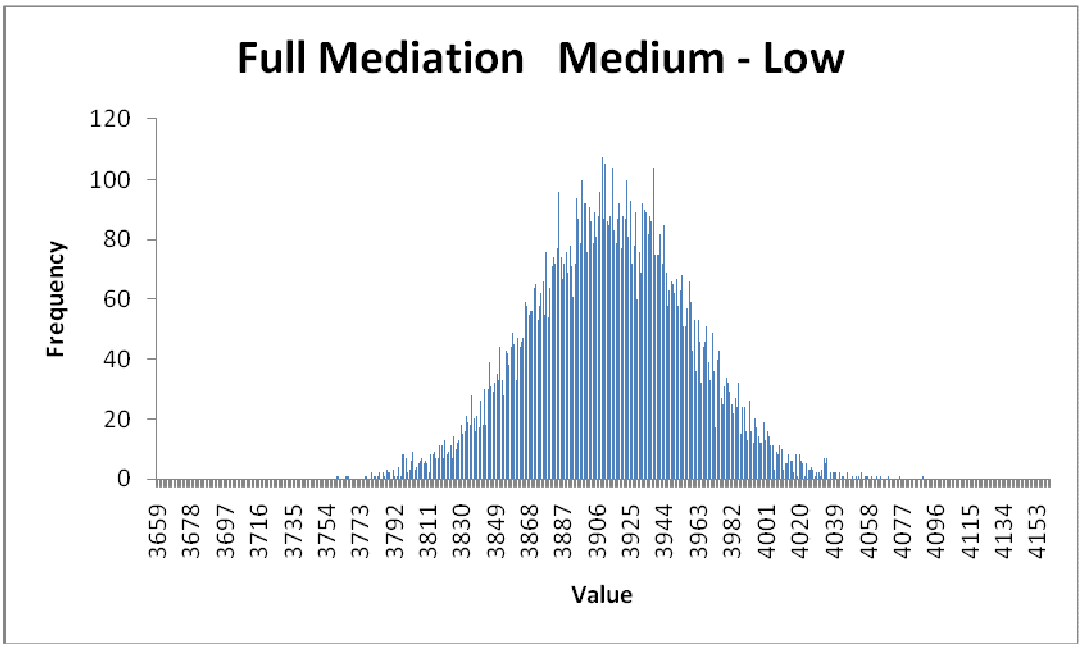


Figure 4.19: Full Mediation Model with Estimates on Medium - Low

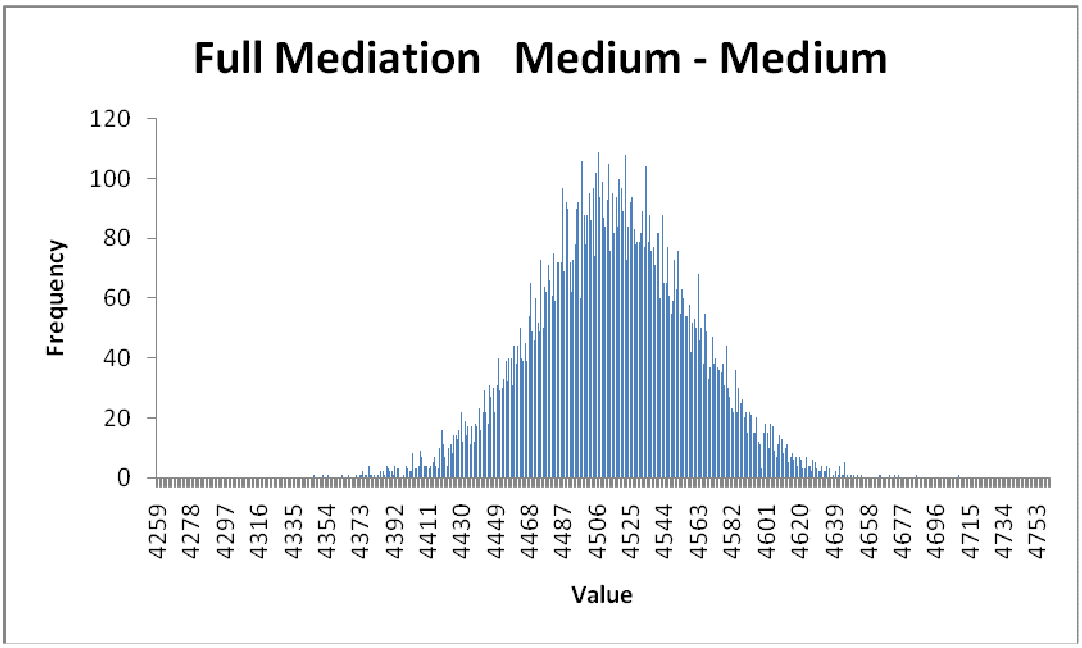


Figure 4.20: Full Mediation Model with Estimates on Medium - Medium

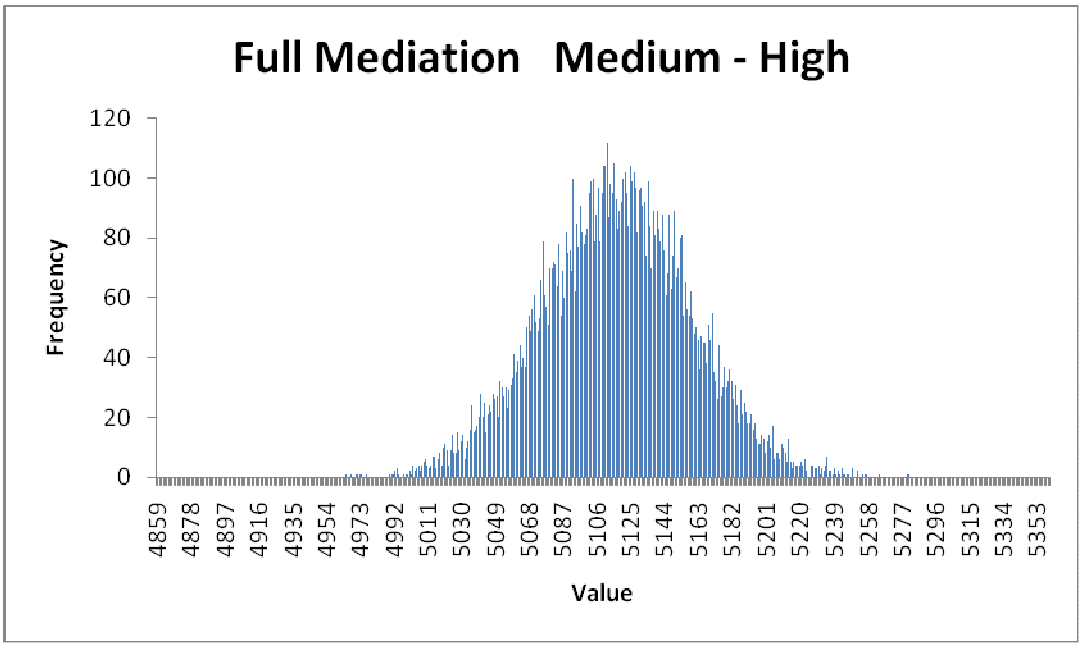


Figure 4.21: Full Mediation Model with Estimates on Medium - High

Figures 4.19, 4.20, and 4.21 represent the fully mediated model with the first layer set to “medium” and the second layer set to the three different estimates “low”, “medium”, and “high”. It can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 602 points when the estimates in layer two are increased.

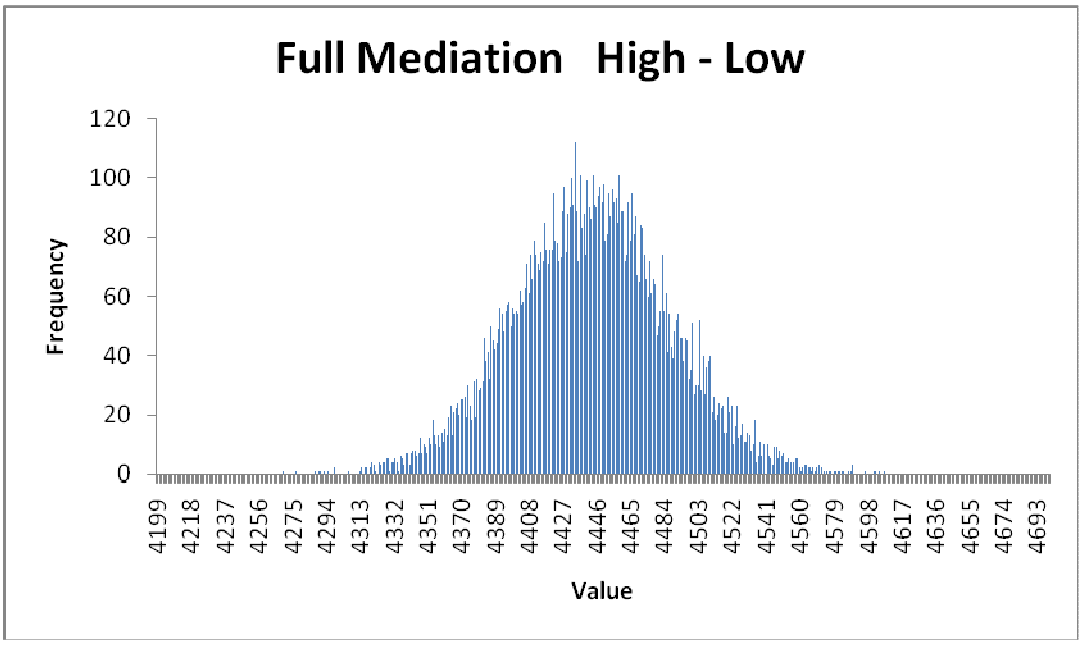


Figure 4.22: Full Mediation Model with Estimates on High - Low

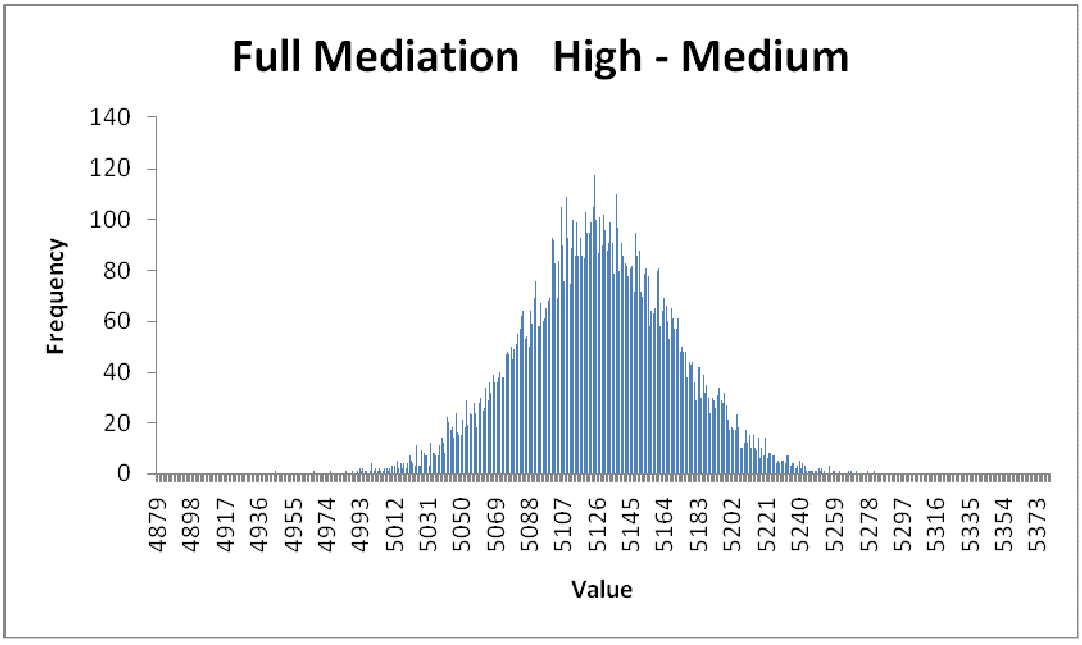


Figure 4.23: Full Mediation Model with Estimates on High - Medium

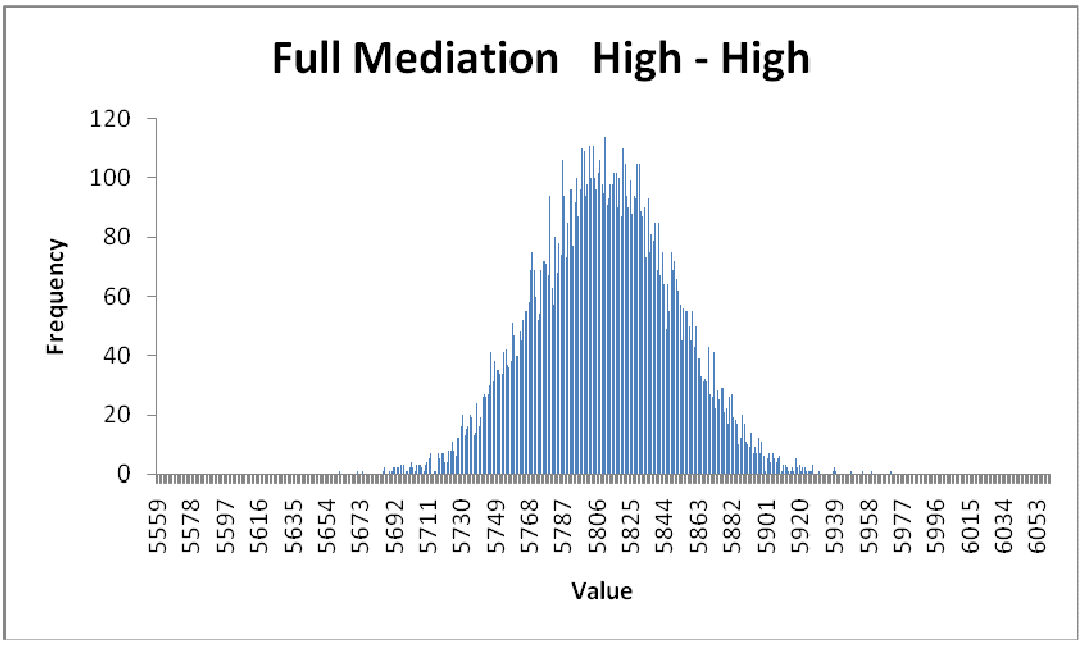


Figure 4.24: Full Mediation Model with Estimates on High - High

Figures 4.22, 4.23, and 4.24 represent the fully mediated model with the first layer set to “high” and the second layer set to the three different estimates “low”, “medium”, and “high”. It can be seen that the shape of the distribution does not change by a change in estimates. In addition the mean increases by 684 points when the estimates in layer two are changed from “low” to “medium” and by 683 points when the estimates are changed from “medium” to “high”.

In addition to the observations made when the estimates for the second layer are changed and the estimates for the first layer are kept stable, there is also a pattern to be observed when layer two is kept stable and the estimates in layer one are changed.

4.5.2 The Means

Figures 4.25, 4.26, and 4.27 present the total value of the means for different settings in the three models. The first two models for the fully mediated and partially mediated model use the same scales to allow better comparison of the diagrams. Figure 4.27 shows a two dimensional model representing the means in the unmediated model while figures 4.25 and 4.26 show a three dimensional model representing the fully mediated and the partially mediated model.

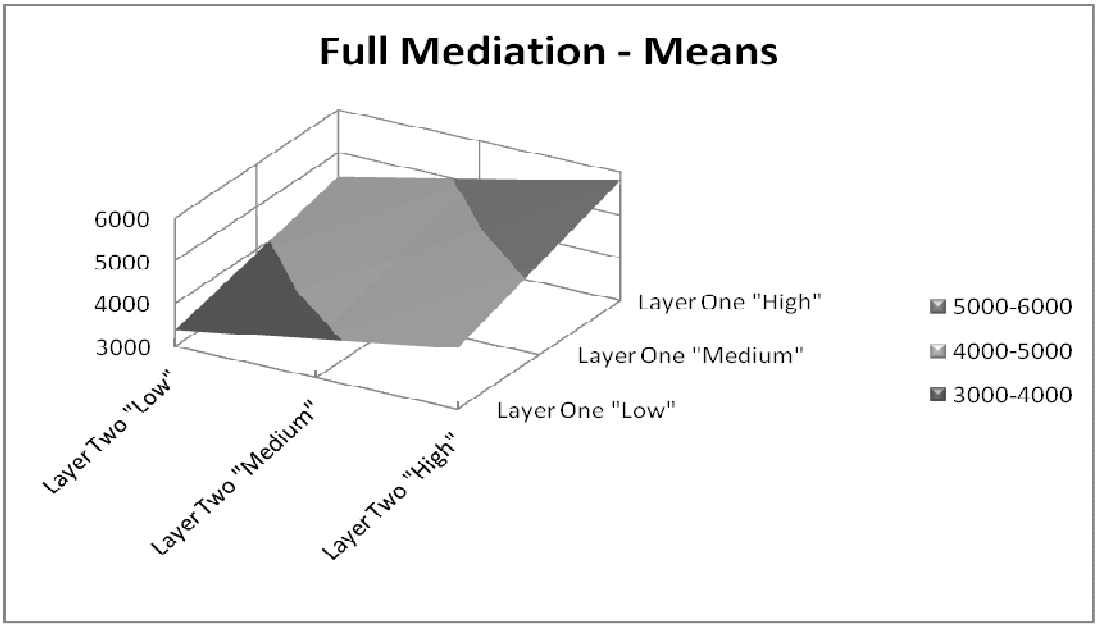


Figure 4.25: Fully Mediated Model – Means of the Distributions

Figure 4.25 presents a three dimensional diagram of the total means in the fully mediated model. The diagram shows the linearity between the means for the 9 different settings. It can be seen that the change in estimates for layer one has a higher effect on the means than the change in layer two. The slight bend in the middle of the diagram can be explained by the rounding errors regarding the means and by slight variation in the results of the simulation because of the limitation to 10,000 runs per setting.

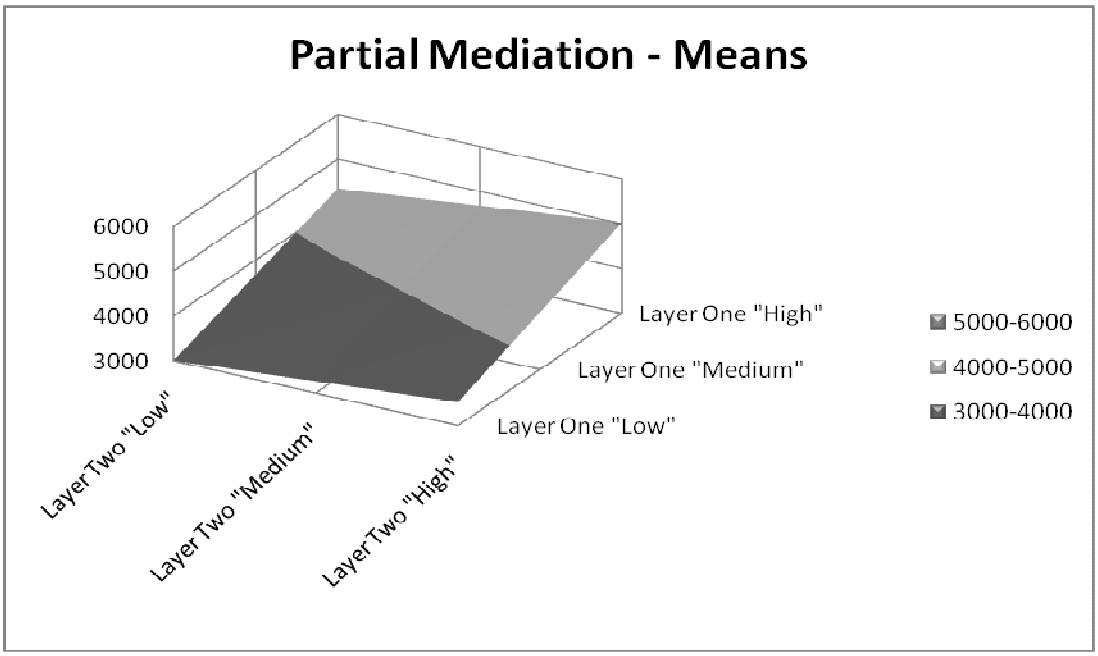


Figure 4.26: Partially Mediated Model – Means of the Distributions

Figure 4.26 presents a three dimensional diagram of the total means in the partially mediated model. The diagram clearly shows the linearity between the means for the 9 different settings. It can be seen that the change in estimates for layer one has a much higher effect on the means than the change in layer two. Compared to Figure 4.25 the higher effect of layer one changes on the results of the simulation has increased.

The diagram for the unmediated model shows a similar pattern. Due to the independence of the layer one and layer two constructs, the diagram for the unmediated model is two dimensional.

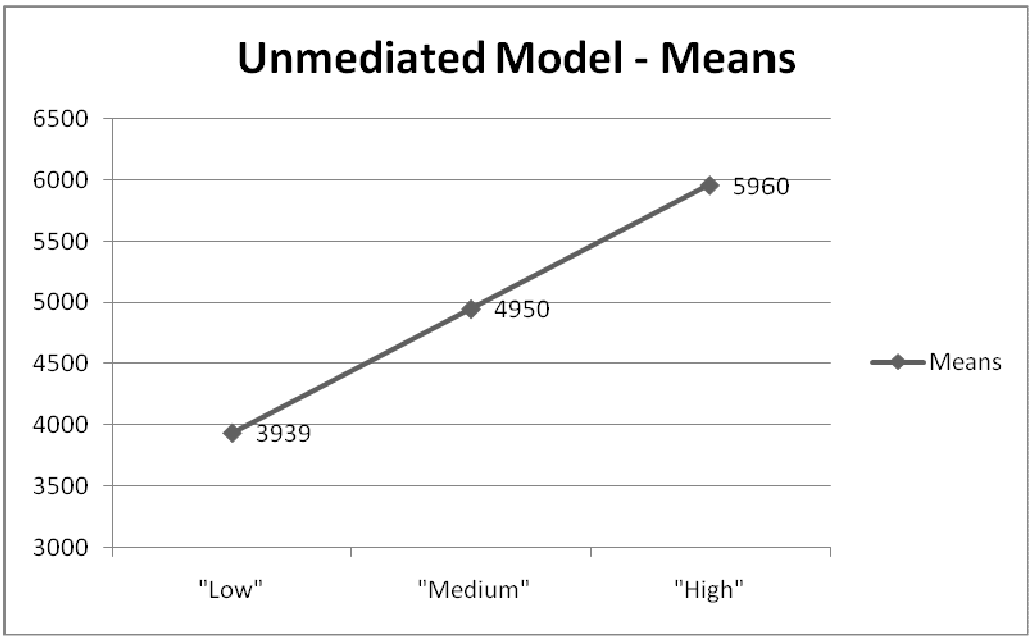


Figure 4.27: Unmediated Model – Means of the Distributions

Figure 27 shows the total value of the means for the three different estimates in the unmediated model. The linearity in the change of the means can be seen clearly. The slight bend in the middle can be explained through rounding errors and the limitation to 10,000 runs. The total change in means is presented in the table form with each table representing one of the models. The first table will present the results for the unmediated model.

Table 4.2: Unmediated Model – Changes in Means

Unmediated Model	Low – Low	Medium – Medium	High – High
Low – Low		1011	2021
Medium – Medium	-1011		1010
High – High	-2021	-1010	

The linearity in the change of means can be seen in Table 4.2. The mean changes by 1011 point when the estimates switch between “low” and “medium” and by 1010 for switches between “medium” and “high”. Again the slight difference in values can be explained by rounding errors or the limited number of runs.

The following two table use L as replacement for “low”, M for “medium” and H for “high” in order to allow the results to be presented in one table. The two tables are ordered by the estimates for the first layer. These estimates increase on both axis from L – L to H – H.

Table 4.3: Full Mediation – Changes in Means ordered by Layer One

Full Mediation	L – L	L – M	L – H	M – L	M – M	M – H	H – L	H – M	H – H
L – L		520	1040	531	1133	1735	1061	1745	2428
L – M	-520		520	11	613	1215	541	1225	1908
L – H	-1040	-520		-509	93	695	21	705	1388
M – L	-531	-11	509		602	1204	530	1214	1897
M – M	-1133	-613	-93	-602		602	-72	612	1295
M – H	-1735	-1215	-695	-1204	-602		-674	10	693
H – L	-1061	-541	-21	-530	72	674		684	1367
H – M	-1745	-1225	-705	-1214	-612	-10	-684		683
H – H	-2428	-1908	-1388	-1897	-1295	-693	-1367	-683	

Table 4.3 includes the difference in the means for each possible change of settings in the fully mediated model. The pattern that emerges can be seen in each set of nine boxes that represent the change in means for nine different combinations of estimates in layer two regarding one connection between two estimates in layer one.

Table 4.4: Partial Mediation – Changes in Means ordered by Layer One

Partial Mediation	L – L	L – M	L – H	M – L	M – M	M – H	H – L	H – M	H – H
L – L		260	520	669	971	1272	1339	1681	2023
L – M	-260		260	409	711	1012	1079	1421	1763
L – H	-520	-260		149	451	752	819	1161	1503
M – L	-669	-409	-149		302	603	670	1012	1354
M – M	-971	-711	-451	-302		301	368	710	1052
M – H	-1272	-1012	-752	-603	-301		67	409	751
H – L	-1339	-1079	-819	-670	-368	-67		342	684
H – M	-1681	-1421	-1161	-1012	-710	-409	-342		342
H – H	-2023	-1763	-1503	-1354	-1052	-751	-684	-342	

As an example one of these groups has been highlighted in Table 2. The highlighted group shows that the means change by 520 points for each horizontal change and by 602 points for each vertical change.

This table represents the change in means for each change in estimates in the partially mediated model. The same pattern that was observed in Table 2 does emerge in this table. On example was highlighted to show that the same pattern is valid in this table.

The following two tables show the same content but ordered by the second layer estimates. Through the changed order it is possible to visually identify the linearity in the development of the means for changes in the layer two estimates.

Table 4.5: Full Mediation – Changes in Means ordered by Layer Two

Full Mediation	L – L	M – L	H – L	L – M	M – M	H – M	L – H	M – H	H – H
L – L		531	1061	520	1133	1745	1040	1735	2428
M – L	-531		530	-11	602	1214	509	1204	1897
H – L	-1061	-530		-541	72	684	-21	674	1367
L – M	-520	11	541		613	1225	520	1215	1908
M – M	-1133	-602	-72	-613		612	-93	602	1295
H – M	-1745	-1214	-684	-1225	-612		-705	-10	683
L – H	-1040	-509	21	-520	93	705		695	1388
M – H	-1735	-1204	-674	-1215	-602	10	-695		693
H – H	-2428	-1897	-1367	-1908	-1295	-683	-1388	-693	

Table 4.6: Partial Mediation – Changes in Means ordered by Layer Two

Partial Mediation	L – L	M – L	H – L	L – M	M – M	H – M	L – H	M – H	H – H
L – L		669	1339	260	971	1681	521	1272	2023
M – L	-669		670	-410	301	1012	-149	602	1353
H – L	-1339	-670		-1079	-368	342	-819	-68	684
L – M	-260	410	1079		711	1421	261	1012	1763
M – M	-971	-301	368	-711		710	-450	301	1052
H – M	-1681	-1012	-342	-1421	-710		-1161	-410	342
L – H	-521	149	819	-261	450	1161		751	1502
M – H	-1272	-602	68	-1012	-301	410	-751		751
H – H	-2023	-1353	-684	-1763	-1052	-342	-1502	-751	

Tables 4.5 and 4.6 also show the pattern that was observed in Tables 4.3 and 4.4. Therefore it can be noted that every change in estimates is followed by a clearly defined change in the means of the distribution.

4.5.3 Repetitions of the Simulation

Figures 4.28, 4.29, and 4.30 show the distribution for the fully mediated model with layer one set on “medium” and layer two set on “low”. The model and combination of estimates were chosen randomly. The difference is that the first diagram shows the results after 1.000 simulation runs while the second diagram shows the result after 10.000 runs and the third diagram shows the results after 100.000 runs of the simulation. We can clearly see that the shape of the distribution is still the same and within the same range of values.

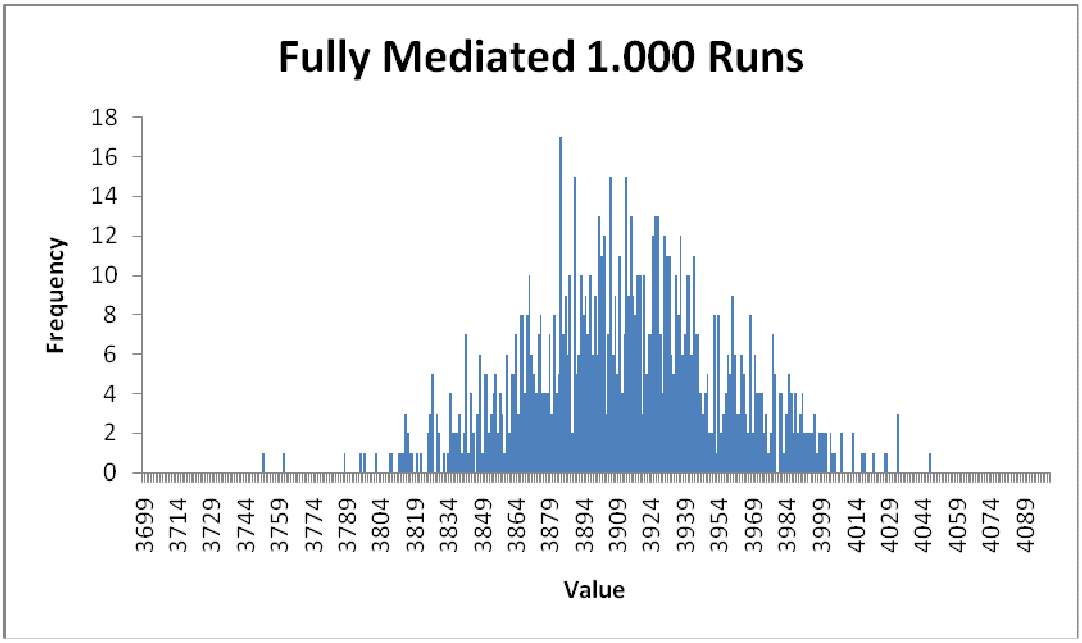


Figure 4.28: Distribution of the Fully Mediated Model after 1,000 Runs

Figure 28 shows the results for the simulation run of the fully mediated model with layer one set on “medium” and layer two set on “low”. The distribution is the result of 1,000 runs of this simulation. It can be seen that the normal distribution is about to emerge even though there are clearly some peaks. The mean of this distribution is at 3913 which means that 48.91% of the input values were put through the model. The minimum value encountered during the simulation was 3752 and the maximum was 4047. The range of output values is 295 or 3.69% of the total range of values.

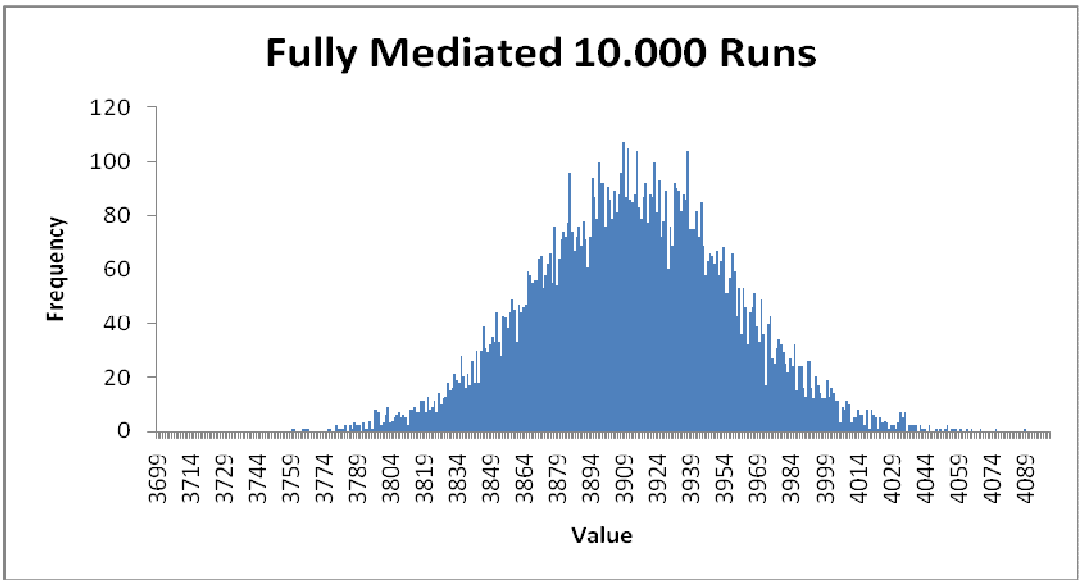


Figure 4.29: Distribution of the Fully Mediated Model after 10,000 Runs

Figure 29 shows the results for 10,000 simulation runs of the fully mediated model with layer one set on “medium” and layer two set on “low”. Compared to the simulation with 1,000 runs the distribution looks much more like a normal distribution even though there are still some peaks. The mean of this distribution is at 3913 which means that 48.91% of the input values were put through the model. The mean is therefore exactly the same as in the previous simulation with 1,000 runs. The minimum value encountered during the simulation was 3760 and the maximum was 4089. The range of output values is 329 or 4.11% of the total range of values. The increase in the range of output values compared to the 1,000 runs simulation is 34 or 11.53%.

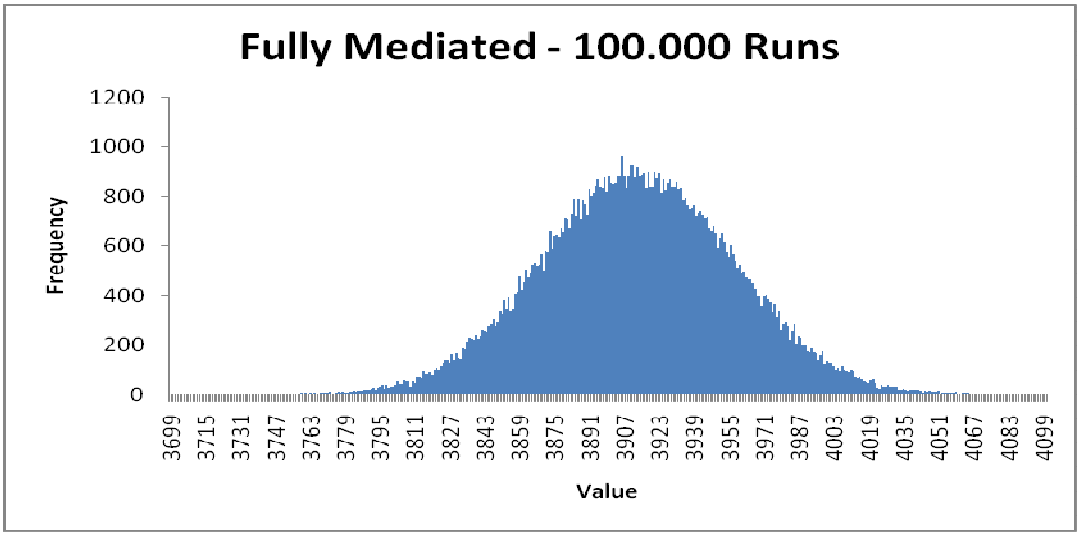


Figure 4.30: Distribution of the Fully Mediated Model after 100,000 Runs

Figure 30 shows the distribution for 100,000 simulation runs of the fully mediated model with layer one set on “medium” and layer two set on “low”. Compared to the simulations with 1,000 and 10,000 runs the distribution looks even more like a perfect normal distribution. The mean of this distribution is at 3913 which means that 48.91% of the input values were put through the model. The mean is therefore exactly the same as in the previous simulations with 1,000 and 10,000 runs. The minimum value encountered during the simulation was 3709 and the maximum was 4098. The range of output values is 389 or 4.86% of the total range of values. The increase in the range of output values compared to the 1,000 runs simulation is 94 or 31.86% and compared to the 10,000 runs simulation the increase is 67 or 18.24%.

4.6 SUMMARY

This chapter contained the presentation and analysis of the results of the simulation. Therefore a sensitivity analysis was conducted on the results of simulation. In addition the problems experienced during the execution of the simulation were reported.

The sensitivity analysis identified that the distributions of the results of the different settings create the same form of normal distribution. In addition a pattern was identified that clearly connects every change of setting to a certain change in the means of the distribution. The pattern shows linearity between every change of setting and the subsequently changed means.

Section 4.5.3 showed the increased accuracy of the distributions when the number of runs is increased. Therefore three different diagrams representing the same setting in the same model for three different numbers of runs were presented.

The next chapter presents a discussion and interpretation of the findings. Therefore the identified findings are interpreted and connected with the previously researched literature. The limitations of the research and recommendations for further research are also presented.

Chapter 5 – Discussion

5.0 INTRODUCTION

In this chapter the findings identified in Chapter 4 are discussed. Therefore the results are analysed and compared to findings of previous studies and to the expected outcomes defined in Section 3.5.2. The most important finding is that the proposed models are stable and that the changes in the model results follow a linear pattern. This linearity allows predictability of the expected outcomes of the simulation and allows benchmarking against the results.

This chapter will first present a discussion of the results regarding sensitivity analysis followed by a more extensive discussion of the linearity of the model and the possibilities that arise through linearity. Next a discussion of the hypotheses and the main research question in regard of the results of the simulation is presented. Finally a summary and conclusion of this chapter is presented. Therefore this Chapter is divided into three sections. Section 5.1 presents and discussed the findings of this thesis. The subsections are for the sensitivity analysis, for an analysis of the simulation outcomes, and a subsection for a comparison of the expected outcomes versus the actual outcomes are presented. Section 5.2 presents and discusses the implications of the identified linearity in the changes of the simulation outcomes for changes in the estimates. Section 5.3 presents a discussion of the hypotheses and the main research question in regard of the results identified and discussed in the previous sections. Section 5.4 presents a summary of the discussion and findings made in this chapter.

5.1 DISCUSSION OF FINDINGS

In this section the findings of Chapter 4 are reviewed and discussed. To analyse the different aspects of the research the section contains three subsections. The first subsection is concerned with the discussion of the findings regarding sensitivity analysis. Therefore the findings for the changes in parameters and the changes to the number of runs are presented and discussed. The second subsection presents and discussed the results of the simulation and connects the findings with the previously reviewed studies. The last subsection compares the actual findings with the expected outcomes presented in Section 3.5.3. The focus is on identifying

findings that were similar to those proposed and findings that were different than the proposed findings in the theoretical outcomes section.

5.1.1 Sensitivity Analysis

This section focuses on the discussion of the sensitivity analysis. The outline of how sensitivity analysis is implemented in this thesis is outlined in Section 3.4.4. The findings regarding sensitivity analysis are reported in Section 4.5. To discuss sensitivity analysis the results are analysed and compared to findings of previous studies.

The main findings regarding sensitivity of the proposed model are that the model is stable when changes are made to the throughput parameters or the number of runs of the simulation. In every case the distribution of the simulation result presented a normal distribution with similar shape. A large number of runs presented a smoother curve for the distribution than a small number of runs.

The models were tested in three different settings for each parameter. These settings were called minimum, maximum, and estimated value of the specific construct. The estimated value was derived from a review of previous studies and set as a percentage of throughputs for each of the possible relationships between the constructs and variables. The minimum and maximum values represent a change of 10 percent points in every direction.

The simulation was performed with 1,000, 10,000, and 100,000 runs. The result of these changes to the number of runs has shown a higher accuracy and a much smoother distribution of the results. Diagrams representing the distribution for the different number of runs can be seen in Section 4.5.3.

The number of runs and the changes to the parameters and their contribution to the findings of this thesis are presented in more detail in the following two sections.

5.1.1.1 Repetitions of the Simulation

The results of Section 4.5.3 show that there is no change in the means of the distributions for the simulation with 3 different numbers of runs. The full mediation model with estimates set on “medium” for layer one and “low” for layer two was chosen randomly to perform this analysis. The only change that could be observed was that the total range of values for the results of the

simulation increased when the number of runs increased. In the presented model the range of values increased by a maximum of 31.86% for the change from 1,000 runs to 100,000 runs and by a minimum of 11.53% for the change from 1,000 runs to 10,000 runs. The increase of the range of values for the change from 10,000 runs to 100,000 runs was measured as 18.24%.

The changes can be explained by chance. The input values were created using a Monte Carlo method and are therefore totally random. The fact that for every value that gets put through to customer service a new value is randomly generated allows fluctuation in the results of the simulation runs. When the number of runs increases, the chance for extremely low or high results of a single simulation run increase as well. For example the comparison of the different number of runs presented in Section 4.5.3 showed a lower minimum value in the 1,000 runs simulation with 3752 points than in the 10,000 runs simulation with 3760 points.

The fact that the mean of the distribution was constant at 3913 throughput values in all 3 cases shows that the total number of runs did not change the overall results of the simulation. This analysis shows that stability in the proposed models was achieved and that a higher number of runs does increase the accuracy of the simulation but does not change the results.

5.1.1.2 Parameter Changes

For each of the three path models and the included relationships three different throughput parameters were defined. These parameters represent the estimated value, the minimum value, and the maximum value of throughput for the relationships. The estimated value was derived from literature. For more information regarding the definition of estimates see Section 3.4.2. These three estimates were called “low”, “medium”, and “high”. The main reason for the definition of three different estimates for each construct was to perform sensitivity analysis and to observe the variation in the results of the different models under different settings. It has to be considered that the results that are discussed here are based solely on estimates. This means that no real-life data was available to confirm the findings of the simulation. Therefore the discussion in this section is not trying to achieve validity of the outcomes of the simulation but rather aims to

identify and discuss the behaviour of the model under different circumstances. The findings of the sensitivity analysis are presented in Section 4.5.1.

Each change of estimate was followed by a certain variation in the results of the simulation. The tables representing the change in the means for each distribution are presented in Section 4.5.1.

Table 5.1 presents the variation in the means of the distributions for the unmediated model. Since layer one and layer two are seen as independent, they only change their estimates combined.

Table 5.1: Differences in the Means of the Unmediated Model

Unmediated Model	Low – Low	Medium – Medium	High – High
Low – Low		1011	2021
Medium – Medium	-1011		1010
High – High	-2021	-1010	

The results indicate that every change in estimates causes a certain change in the means of the distribution. In the case of the unmediated model every change from "low" to "medium" or from "medium" to "high" in the estimates causes the mean to change by an average of 1010.5 points. A change from "low" to "high" causes a change of 2011 points in the mean of the distributions. The mean in this case describes the average number of values that get put through from the constructs to the business value variable. The total number of created values for the constructs is 10,000 or 2,000 for each of the five constructs. An increase of the mean by approximately 1000 points therefore means that an additional 10% of the initially created values get put through.

The linear change of means indicates that an increase of the defined throughput for the relationship of the constructs and the business value variable by 10% points causes the model to increase the output in relation to the total number of generated values by an average of 10.105%. In terms of the research model, that would mean that an increase of 10% points in service reliability, service efficiency, service consistency, client orientation, and customer service would create an additional value of 10% to the business. The constraint in this model is that the five constructs are all defined as being independent from each other, which is not very likely. The reviewed literature clearly suggests a relationship

between service reliability, service efficiency, service consistency, and client orientation on the one side and customer service on the other. The other two path models are much more likely to represent a real-life relationship of the constructs and variables.

The following tables present the changes of the means for each possible setting of the fully mediated model. The first table presents the changes ordered by the layer one estimates while the second table presents the changes ordered by the second layer estimates. These tables are much more complex than the table regarding the unmediated model because layer one and layer two are seen as dependent in the fully mediated model.

Table 5.2: Differences in the Means of the Fully Mediated Model by Layer One

Full Mediation	L – L	L – M	L – H	M – L	M – M	M – H	H – L	H – M	H – H
L – L		520	1040	531	1133	1735	1061	1745	2428
L – M	-520		520	11	613	1215	541	1225	1908
L – H	-1040	-520		-509	93	695	21	705	1388
M – L	-531	-11	509		602	1204	530	1214	1897
M – M	-1133	-613	-93	-602		602	-72	612	1295
M – H	-1735	-1215	-695	-1204	-602		-674	10	693
H – L	-1061	-541	-21	-530	72	674		684	1367
H – M	-1745	-1225	-705	-1214	-612	-10	-684		683
H – H	-2428	-1908	-1388	-1897	-1295	-693	-1367	-683	

Table 5.3: Differences in the Means of the Fully Mediated Model by Layer Two

Full Mediation	L – L	M – L	H – L	L – M	M – M	H – M	L – H	M – H	H – H
L – L		531	1061	520	1133	1745	1040	1735	2428
M – L	-531		530	-11	602	1214	509	1204	1897

H – L	-1061	-530		-541	72	684	-21	674	1367
L – M	-520	11	541		613	1225	520	1215	1908
M – M	-1133	-602	-72	-613		612	-93	602	1295
H – M	-1745	-1214	-684	-1225	-612		-705	-10	683
L – H	-1040	-509	21	-520	93	705		695	1388
M – H	-1735	-1204	-674	-1215	-602	10	-695		693
H – H	-2428	-1897	-1367	-1908	-1295	-683	-1388	-693	

The underlying pattern in tables 5.2 and 5.3 is explained in more detail in Section 4.5.2. This section discusses the meaning of this pattern. The most important point identified in the findings section is that the results of the simulation increase in a linear fashion no matter which estimate is increased. Another important finding was that the result increases more when layer one estimates are increased than when layer two estimates are increased. That fact can also be seen in Figure 4.25. In the fully mediated model the average increase in percent for layer one changes is approximately 14.62% while the average increase in percent for layer two changes is approximately 14.36%.

This means that an increase in the layer one constructs has a slightly more beneficiary effect on the creation of business value than an increase of the throughput from customer service to business value. It has to be noted that it can't be clearly identified whether the difference in layer one and layer two changes in the fully mediated model is an actual difference or a difference perceived by chance.

Another important findings is that the percentage of increase is higher for changes from "low" estimates to "medium" estimates that from "medium" medium to "high" estimates. In the fully mediated model the average increase in percent for each layer one change from "low" to "medium" is approximately 15.71% and for each change from "medium" to "high" the average increase in percent is approximately 13.54%. The average increase in percent for each layer two change from "low" to "medium" is approximately 15.39% and for each change from "medium" to "high" the average increase is approximately 13.33%. This means that an increase of throughput on a lower basis does create more

additional value than an increase on a higher basis. Therefore companies should find out their least contributing factors and increase those in order to achieve a more beneficiary effect on the creation of additional business value.

The following tables present the changes of the means for each possible setting of the estimates in the partially mediated model. The first table presents the changes ordered by the layer one estimates while the second table presents the changes ordered by the second layer estimates. These tables are much more complex than the table regarding the unmediated model because layer one and layer two are seen as independent in the partially mediated model.

Table 5.4: Differences in the Means of the Partially Mediated Model by Layer One

Partial Mediation	L – L	L – M	L – H	M – L	M – M	M – H	H – L	H – M	H – H
L – L		260	520	669	971	1272	1339	1681	2023
L – M	-260		260	409	711	1012	1079	1421	1763
L – H	-520	-260		149	451	752	819	1161	1503
M – L	-669	-409	-149		302	603	670	1012	1354
M – M	-971	-711	-451	-302		301	368	710	1052
M – H	-1272	-1012	-752	-603	-301		67	409	751
H – L	-1339	-1079	-819	-670	-368	-67		342	684
H – M	-1681	-1421	-1161	-1012	-710	-409	-342		342
H – H	-2023	-1763	-1503	-1354	-1052	-751	-684	-342	

Table 5.5: Differences in the Means of the Partially Mediated Model by Layer One

Partial Mediation	L – L	M – L	H – L	L – M	M – M	H – M	L – H	M – H	H – H
L – L		669	1339	260	971	1681	521	1272	2023
M – L	-669		670	-410	301	1012	-149	602	1353
H – L	-1339	-670		-1079	-368	342	-819	-68	684

L – M	-260	410	1079		711	1421	261	1012	1763
M – M	-971	-301	368	-711		710	-450	301	1052
H – M	-1681	-1012	-342	-1421	-710		-1161	-410	342
L – H	-521	149	819	-261	450	1161		751	1502
M – H	-1272	-602	68	-1012	-301	410	-751		751
H – H	-2023	-1353	-684	-1763	-1052	-342	-1502	-751	

The underlying pattern in tables 5.2 and 5.3 is explained in more detail in Section 4.5.2. This section discusses the meaning of the pattern. The most important point identified in the findings section is that the results of the simulation increase in a linear fashion no matter which estimate is increased. Another important finding was that the result increases more when layer one estimates are increased than when layer two estimates are increased. That fact can also be seen in Figure 4.26. In the partially mediated model the average increase in percent for layer one changes is approximately 19.84% while the average increase in percent for layer two changes is approximately 7.93%. This means that an increase in the layer one constructs has a more beneficiary effect on the creation of business value than an increase of the throughput from customer service to business value.

Another important findings is that the percentage of increase is higher for changes from “low” estimates to “medium” estimates that from “medium” medium to “high” estimates. In the partially mediated model the average increase in percent for each layer one change from “low” to “medium” is approximately 21.79% and for each change from “medium” to “high” the average increase in percent is approximately 17.89%. The increase in percent for changes in layer two from “low” to “medium” is approximately 8.24% while the change from “medium” to “high” is approximately 7.62%. This means that an increase of throughput on a lower basis does create more additional value than an increase on a higher basis. Therefore companies should find out their least contributing factors and increase those in order to achieve a more beneficiary effect on the creation of additional business value.

Table 5.6 shows the changes of the means in percent for the fully mediated and the partially mediated model. L represents the estimate level “low” while M represents “medium” and H represents “high”. All numbers are in percent.

Table 5.6: Relative Mean Changes

	Layer One L to M	Layer One M to H	Layer One Average	Layer Two L to M	Layer Two M to H	Layer Two Average
Fully Mediated	15.71	13.54	14.62	15.39	13.33	14.36
Partially Mediated	21.79	17.89	19.84	8.24	7.62	7.93

Table 5.6 clearly shows that both models experience a more beneficiary effect of changes in estimates on a lower basis. In addition we can see that the partially mediated model showed a stronger reaction to changes than the fully mediated model. Especially the influence of layer one changes on the results of the simulations is much higher in the partially mediated model than in the fully mediated model.

5.1.2 Analysis of Simulation Outcomes

This section presents an analysis of the outcomes of the simulation for all three models with the estimates for each layer set on “medium”. Therefore the results from Section 4.2 are compared and discussed in more detail. For the distributions of the simulation results refer to figures 4.1, 4.2, and 4.3. The estimates set on “medium” represent the most likely percentage of throughput for each of the relationships. These estimates were derived from the review of previous studies. It has to be considered that the results that are discussed here are based solely on estimates. This means that no real-life data was available to confirm the findings of the simulation. Therefore the discussion in this section is not trying to achieve validity of the outcomes of the simulation but rather aims to identify and discuss the behaviour of the model under different circumstances.

The total throughput and the percentage of throughput for each of the models are shown in table 5.7.

Table 5.7: Comparison of the Throughput

	Total number of input values	Total number of values put through	Percentage of values put through
Unmediated	10,000	4950	49.50

Model			
Partially Mediated Model	8,000	3975	49.68
Fully Mediated Model	8,000	4515	56.44

Table 5.7 indicates that the fully mediated model created the most additional value to the business with 56.44 percent. The partially mediated model follows with 49.68 percent and the lowest percentage is represented by the unmediated model with 49.50 percent. Therefore the fully mediated model would represent the best case for any organization that is using ITIL considering the creation of business value through improved customer service. In terms of the real-life relationships between the four constructs, the customer service, variable, and the business value variable the author's opinion is that it is most likely that the partial mediation model includes the best representation of the real-life relations.

Surprisingly the partially mediated model and the unmediated model show almost the same result. Seeing the results from the unmediated model and the fully mediated model it was expected that the partially mediated model would be somewhere in between. Compared to the fully mediated model it contains the same relationships with the same estimates, but compared to the unmediated model the role of customer service as construct that receives input in the form of randomly created data is missing. In the partially mediated model the customer service variable exclusively processes the input received from the four primary constructs. Therefore the missing contribution of customer service to business value explains the difference between the actual and the expected outcome.

Conclusively the full mediation model can be defined as the best case scenario for the positive impact of improved customer service based on benefits delivered through the use of ITIL on the creation of business value. This analysis does not make any assumptions about the probability that the models present the real-life relationships between the four constructs, customer service, and business value.

5.1.3 Actual Outcomes vs. Expected Outcomes

This section compares the actual outcomes of the simulation with the expected outcomes defined in Section 3.5.2. The author expected all of the constructs to contribute to the creation of business value even though some were seen as more likely than others. The most likely contributor was improved client orientation while the least likely contributor was improved service consistency.

The result of the simulation show that every construct contributed to the result of the simulation in all of the tested path ways. The results for each of the three tested models are outline below.

In the partially mediated model the service efficiency construct was identified as the highest contributor with approximately 58.1 percent of throughput followed by the service reliability construct with approximately 54.2 percent of throughput. Service reliability was closely followed by client orientation with a throughput of approximately 53.7 percent. The least contribution construct was service consistency with 34.2 percent of throughput. This means that in the case of the partially mediated model service reliability, service efficiency, and client orientation were high contributors to the success while service consistency did not tribute as much as the other three constructs.

Improved customer service based on the adoption of ITIL could not be identified as a contributor to the creation of business value in all three models. While customer service contributed to business value in all three models, the assumption that the contribution is based on the impact of an ITIL adoption is only valid in the fully mediated model and the partially mediated model. The unmediated model does not allow verification of the assumption that the use of ITIL is responsible for the beneficiary effect of customer service on business value, because the four constructs in layer one and customer service are defined as being independent from each other in the unmediated model.

In the fully mediated model the greatest contributing factor is client orientation with approximately 63.9 percent of throughput followed by service efficiency with approximately 56.4 percent and service reliability with approximately 56.3 percent. Again the least contribution factor is service consistency with approximately 46.4 percent.

In the unmediated model the throughput equals the “medium” estimates for each of the constructs because there is no additional processing of the values through the customer service variable. Therefore the highest contributor is service

efficiency with 60 percent throughput followed by service reliability with 50 percent throughput. The least contributing factors are service consistency and client orientation with only 30 percent throughput each.

Unfortunately the results of this thesis are not able to support the claims of the OGC (2007a) that ITIL provides a lot of benefits for organizations that adopt ITIL. In addition the results are not able to support the findings of other studies that were concerned with the benefits of ITIL. This is due to the fact that the results are solely based on estimates retrieved from a literature review and that a change in estimates would have changed the outcome of the model. The lack of real-life data does not allow any conclusions as to whether the claims can be realised or not.

The model that delivers the best results was already identified in Section 5.1.2 and is the fully mediated model. The fully mediated model was also identified as the model with the highest probability for the best results.

Table 5.8 presents an overview of the contribution of the four constructs, service reliability, service efficiency, service consistency, and client orientation to the results of the three path models. All numbers are in percent.

Table 5.8: Contribution of Constructs

	Service Reliability	Service Efficiency	Service Consistency	Client Orientation
Unmediated Model	50.0	60.0	30.0	30.0
Partially Mediated Model	54.2	58.1	34.2	53.7
Fully Mediated Model	56.3	56.4	46.4	63.9

This table shows that service reliability and service efficiency are contributing between 50 percent and 60 percent of their inputs to the results of the simulations in each of the three models. Client orientation is highly contributing in the partially mediated model and in the fully mediated model, but has a low

contribution in the unmediated model. Service consistency is always contributing less than 50 percent of the input to the results of the simulations with a maximum contribution of 46.4 percent in the fully mediated model. Therefore service reliability, service efficiency, and client orientation, except in the unmediated model, can be seen as high contributors to the generation of business value through improved customer service. Service Consistency can be seen as a medium contributor at best.

5.2 IMPLICATIONS OF THE LINEARITY OF THE MODELS

This section will discuss the implications of the identified linearity of the models. Therefore a general discussion of the meanings of linearity will be presented. After that two subsections will discuss the achieved predictability of the model outcomes and the benchmarking possibilities of an improved model.

The linearity of the differences in the results of the simulations with each possible combination of estimates shows that the results have a clear relation with the estimates of the simulation. Therefore the linearity allows a prediction of the outcomes of the simulation when the input and estimates are known. In addition a test of the model with real-life data could be used to develop a benchmark for comparison of individual results with average results.

5.2.1 Predictability

The predictability of the results when input and estimates for throughput are known allows organizations that think of implementing ITIL to quantitatively predict the impact that the use of ITIL will have on their organization. The predictability of outcomes would be a huge advantage for all forms of organizations. Hochstein et al. (2005a) found that the communication costs concerned with an ITIL implementation, especially the marketing campaigns that aim a higher acceptance on all levels, are not to be underestimated. In regard of these costs and a the general difficulty of motivating top-level management to support high expenses for new IT management practices, a clear predictability of the benefits of such an implementation would have great benefit.

Hochstein et al. (2005a) also found that the lack of acceptance and the often not understood reasons for the need of implementing ITIL are some of the greatest challenges for success of and ITIL adoption. They identified the

demonstration of how ITIL will benefit an organization as one of the most effective initiative to secure support. The predictability of the outcomes would provide an organization with numbers that prove the usefulness of ITIL and that could therefore help to decrease the resistance against change.

In addition to the opportunities that the predictability of the outcomes would offer for internal marketing of an ITIL adoption, there are also some other benefits that could be achieved through the quantification of the benefits of the use of ITIL. Cater-Steel et al. (2006) found that “many of the managers mentioned the difficulty in quantifying benefits” (Cater-Steel et al. 2006, p.8) as one of the challenges that organizations face when they start implementing ITIL. This problem could be solved by providing organizations with a tool to quantitatively predict the outcomes of an ITIL adoption based on the proposed models in this thesis.

To establish a real predictability of the outcomes that can be used to perform a cost-benefit analysis of intended ITIL adoptions further research has to be undertaken in order to develop a way for organizations to develop their individual estimates for each relationship. In addition, companies would have to be able to measure or predict the impact that ITIL will have on the areas that will benefit from an adoption.

5.2.2 Benchmarking

In addition to the advantages of predictability of the outcomes of an ITIL adoption, the models could also provide organizations with a benchmark that would allow a closer investigation of the achieved individual results compared to industry averages.

The general advantage of benchmarking of IT services includes the ability of organizations to measure and compare the performance of a specific service in regard of competing internal and external services. In addition, benchmarking allows organizations to compare the performance of their internal with the performance of the internal services of competitors. Therefore benchmarking enables organizations to identify areas of improvement within their set of services.

The benchmarking ability of the model proposed in this thesis would therefore allow organizations to rate the success of the ITIL adoption not only on qualitative measures but also quantitatively and not only isolated to the company

but also relative to the successes of competitors. This would provide huge benefits for organizations that have implemented ITIL and are currently measuring and evaluating the success of their implementation.

Necessary expectations to achieve this form of benchmarking would be a test of the models with real-life data. Therefore a survey-based quantitative approach that focuses on the achieved benefits of organizations that have already adopted ITIL would be the best way. In addition the survey would also have to collect the data in a way that would allow developing a quantification of the relationships between the achieved benefits and their value to the business.

5.3 RESEARCH QUESTION

This section will discuss the results of the simulation in the context of the hypotheses and the main research question developed in Section 3.3.3. Expectations for the results of the test of the hypotheses are defined in Section 3.5.2. The five hypotheses are defined as follows:

> H1: The use of ITIL will improve customer service through higher reliability of IT services.
> H2: The use of ITIL will improve customer service through higher consistency of IT services.
> H3: The use of ITIL will improve customer service through higher efficiency of IT services.
> H4: The use of ITIL will improve customer service through a higher client orientation of IT departments and the services that they provide.

The results of the simulation show clearly that every construct is contributing to the results of the simulation even though their contribution is different. Service reliability, service efficiency, and client orientation were identified as major contributors to improved business value in all three tested path models. The contribution of service consistency was found to be minor in relation to the three other constructs. Even though service consistency did not contribute as much as the other constructs, service consistency still had a beneficiary effect on business

value and customer service in all three models. Therefore hypotheses 1 to 4 can be regarded as confirmed.

The results of this thesis support parts of the claims of the OGC (2007a) that ITIL provides a lot of benefits for organizations that adopt it. In addition the findings support some of the findings in previous research. The finding of Karimi et al. (2001) that improved reliability of IT services is one the major contributor to improved customer service based on the use of information technology is fully supported by the findings in this thesis. Hochstein et al. (2005a) also found that more reliable services are a benefit of the use of ITIL. Their findings are therefore also supported by the findings of this thesis. In addition the finding of Hochstein et al. (2005a) that improved service efficiency can be realised when ITIL is used, is supported with the result found in this thesis. Potgieter et al. (2005) stated that the use of ITIL improves the consistency of IT services. In this thesis the results of the simulation support their findings regarding improved consistency of services. In addition this thesis supports the findings of Hochstein et.al (2005a) and Potgieter et. al (2005) that the use of ITIL leads to a higher client orientation and therefore improves customer service.

The fifth hypothesis is concerned with the impact of ITIL on the creation of additional business value through improved customer service and is defined as follows:

> H5: The use of ITIL will create value to the business through improved customer service.

The analysis of the simulation results clearly show that improved customer service has a beneficiary effect on business value in each of the three tested path models. The highest impact on the results of the simulation was found in the fully mediated model where all four layer one constructs were constraint to contribute solely to the customer service variable. The impact was found to be still very high in the partial mediation model, but due to the direct relationships between the layer one constructs and the business value variable the influence of customer service on the results of the simulation decreased. In the unmediated model customer service the influence of customer service decreased even more, due to the independence of layer one and layer two. Conclusively it can be said that

improved customer service had a beneficiary effect on business value in all three models, but only in the fully mediated model and in the partially mediated model was this effect due to the use of ITIL. Therefore hypothesis five is just partially confirmed. The findings of other researchers regarding the positive impact of customer service on the creation of business value can be confirmed, but not the findings that see this impact as a result of the use of ITIL.

The main research question was identified in Section 3.3.3 and is defined as stated in Q1:

> Q1: What are the perceived benefits for customer service of the use of the IT Infrastructure Library?

To answer this question the constraints of the simulation approach have to be considered. The author identified four major contributors to improved customer service based on the use of ITIL from a literature review. Therefore only these four possible benefits can be identified in this thesis.

The results of the data analysis clearly indicate that all four of the proposed contributors are indeed contributing to the results of the simulations. Therefore service reliability, service efficiency, service consistency, and client orientation are identified as benefits for customer service of the use of ITIL. To fully answer the research question it would have been necessary to widen the models that have been tested in the simulation and to include all possible benefits for customer service of the use of ITIL. Therefore the main research question cannot be fully answered with the results of the simulation in this thesis. Despite that the four most likely contributors to improved customer service have been identified from literature and were proven to have a beneficiary effect on improved customer service and the creation of additional business value.

5.3 CONCLUSION

This chapter presented a discussion and analysis of the findings of the simulations. Therefore the findings were reviewed, discussed and connected to

findings of other studies that were reviewed in previous chapters. This section will present a summary of Chapter 5 and the main findings.

The most important observation of the results of this thesis is that the proposed models are stable and show linearity in the change of results for the possible settings in each model. The linearity allows predictability of the outcomes when the estimates and the input are known. The predictability could allow a better assessment of the expected impact that the adoption of ITIL will have on an organization that is planning to implement ITIL. In addition, the ability to benchmark the success of an ITIL implementation was also identified as one of the major opportunities that the models in this thesis present. A prerequisite for the realisation of these two opportunities would be a further enhancement of the model and a test with real-life data.

The main findings regarding the results of the simulation are that four of the five hypotheses defined in Section 3.3.3 are supported by the results of the simulation and that four benefits for customer service of the use of ITIL could be identified. For more information regarding the findings see Section 5.1.3. The only hypothesis that is not fully supported is hypothesis 5. The unmediated model did not allow to identify the impact that the benefits of ITIL have on customer service due to the constraint that layer one and layer two have to be independent in that model. Therefore the research question could not be answered fully, but could be answered in regard of the four most likely benefits of the use of ITIL on customer service.

One limitation of this thesis is that the results that are discussed here are based solely on estimates derived from literature. This means that no real-life data was available to confirm the findings of the simulation. Therefore the discussion in this section is not trying to achieve validity of the outcomes of the simulation but rather aims to identify and discuss the behaviour of the model under different circumstances.

Chapter 6 – Conclusion

6.0 CONCLUSION

This chapter presents the final conclusions of the thesis. Therefore a summary of the results of Chapter 4 and Chapter 5 is made. In addition general outlines of the intentions that lead to the development of this thesis are presented. The last two sections are concerned with the limitations of the findings and the recommendations for further research.

The aim of the research was to identify the perceived benefits for the customer of the use of ITIL. To achieve the identification of the benefits, a Monte Carlo based simulation approach was selected as the methodology that suited model testing. An initial research model was developed and the possible path models were identified. A metric model was developed including the estimates for the relationships of the constructs and variables. These estimates were derived from literature. Next constraints for the three different models were defined and the operationalising of the simulation was defined. Finally sensitivity analysis was implemented for further analysis of the simulation results. Chapter 4 presents the findings of the simulation for each of the 21 possible settings within the three different models. In addition the results of the sensitivity analysis and the results for the model with a different number of runs were presented.

The results of the simulation were then analysed and discussed to test the hypotheses and answer the main research question. The findings of the simulation clearly indicate that the proposed models works and that service reliability, service efficiency, service consistency, and client orientation all contribute towards the creation of additional business value. The analysis of the contribution of the four constructs toward improved customer service and the creation of additional business value showed difference between the contribution of the four constructs, but also found that all four constructs are contributing in each of the three path models. Improved customer service based on the use of ITIL could only be identified as a contributor to the creation of business value in the partially mediated model and in the fully mediated model. In the unmediated model a test was not possible, because the layer one constructs and customer service were constraint to be independent from each other.

Therefore the results of this thesis support parts of the claims of the OGC (2007a) that ITIL provides a lot of benefits for organizations that adopt it. In addition the findings support some of the findings in previous research. The finding of Karimi et al. (2001) that improved reliability of IT services is one the major contributor to improved customer service based on the use of information technology is fully supported by the findings. Hochstein et al. (2005a) also found that more reliable services are a benefit of the use of ITIL. Their findings are therefore also supported by the findings of this thesis. In addition the finding of Hochstein et. al (2005a) that improved service efficiency can be realised when ITIL is used, is supported with the result found in this thesis. Potgieter et al. (2005) stated that the use of ITIL improves the consistency of IT services. In this thesis the results of the simulation support their findings regarding improved consistency of services. In addition this thesis supports the findings of Hochstein et.al (2005a) and Potgieter et. al (2005) that the use of ITIL leads to a higher client orientation and therefore improves customer service.

Improved customer service based on the adoption of ITIL could not be identified as a contributor to the creation of business value in all three models. While customer service contributed to business value in all three models, the assumption that the contribution is based on the impact of an ITIL adoption is only valid in the fully mediated model and the partially mediated model. The unmediated model does not allow to verify the assumption that the use of ITIL is responsible for the beneficiary effect of customer service on business value, because the four constructs in layer one and customer service are defined as being independent from each other in the unmediated model. Therefore the findings of previous studies regarding the relationship between customer service and the creation of business value can only be partially supported.

In addition it was identified that the fully mediated model is the model that creates the most output compared to the total number of inputs values with 56.44 percent of throughput. The partially mediated model was identified as being second with 49.68 percent of throughput closely followed by the unmediated model with 49.50 percent.

The answer to the main research question is that improved service reliability, improved service consistency, improved service efficiency, and higher client orientation all have beneficiary effects on customer service. Despite the

finding that the four constructs are contributors to improved customer service, the research question cannot be finally answered. In addition to the four benefits identified as the most likely from a literature review and tested in the developed models, there are other possible benefits for customer service of the use of ITIL that have not been tested in this thesis. These benefits could include improved service transparency, improved service-level agreements, and improved continual service improvement.

The analysis of the simulation with three different numbers of runs showed that the shape of the distribution becomes smoother when the number of runs increases. The means of the distributions for 1,000 runs, 10,000 runs, and a 100,000 runs were exactly the same at 3913 points. The range of output values slight increased when the number of repetitions was increased. The overall increase in the range of values from the 1,000 run simulation to the 100,000 run simulation was 31.86 percent. The analysis of the repetitions showed that the model is stable and that a higher number of runs increase the accuracy of the outcomes, but do not change the results of the simulation. For more information regarding the number of runs refer to Section 5.1.1.1.

The most interesting observation regarding the results and the behaviour of the models is that the change in the results of the simulations with different settings is linear. The linearity was found in all three tested path models. In addition the linearity was also found for each change of layer one or layer two estimates. For more information regarding the linearity of the model see Section 5.2. The possibilities that arise from the linearity are the development of a model that allows the prediction of the outcomes of an ITIL adoption. A quantification of the benefits of an ITIL adoption for an individual organization would present a huge advantage for organizations that are currently thinking of or planning to implement ITIL. In addition the results of the models based on real-life data could provide a source for benchmarking of implementation success and ongoing improvement of the IT services within an organization.

Conclusively the researcher can say that the purpose of this thesis to identify the perceived benefits for customer service of the use of ITIL was fulfilled. Four benefits were identified, namely improved service reliability, improved service consistency, improved service efficiency, and higher client orientation. In addition the identified linearity offers a lot of opportunities for

future research and further improvement of the models with the final target of providing organizations with a tool to predict and evaluate the possible outcomes of an ITIL adoption. The identified benchmarking opportunity based on the models processed with real-life data could provide a useful tool for measurement and improvement of IT services and evaluation of the success of ITIL implementations.

6.1 LIMITATIONS

This section will discuss the limitations of the findings reported in this thesis and especially the limitations that come with a simulation approach based on the Monte Carlo method. General limitations of simulation and specific limitations of the research will be discussed.

A general limitation of this thesis is that the developed and tested models don't consider any influence from other constructs or variables that were not included in the models. Other constructs that were not considered include other possible benefits for customer service of the use of ITIL. These benefits could include for example improved service transparency or decreased transition times for IT services. There are some other factors that could have an impact on customer service and that will be influenced by an ITIL adoption. Especially the impacts of ITIL on other disciplines within an organization are not considered.

One of the risks of the use of simulation methodology is that readers might not be familiar with that approach and that therefore the results of the study are questioned. In business or information technology research the simulation approach is not widely used as a research methodology to date compared to other research disciplines. In areas like physics and medicine the simulation methodology is often used in cases where real-life data is hard to obtain. Therefore this approach is much more accepted in those disciplines.

One of the most critical points in simulation based research is the development of the estimates for the observed variables and constructs. Conrad (2003) notes that estimates are mostly based on the knowledge of experts and that therefore estimates are merely representations of the possible values. In this research the estimates are based almost solely on the qualitative findings of other researchers due to the fact that there is a lack of reliable quantitative data

concerned with benefits of the use of ITIL. Another limitation of the simulation approach is the fact that the model is just a simplified representation of the real-life reference system (Klingstam et al. 1999). In this study the simplification of the proposed models is the one of the major limitations. The number of possible benefits for customer service of the use of ITIL was limited to the four most likely. Even though there are other possible benefits for customer service with ITIL use, the published literature suggests that the selected items are the most likely contributors. To identify the four most likely contributors an extensive literature review has been conducted. The literature review clearly suggested that improved service reliability, improved service consistency, improved service efficiency, and higher client orientation are in fact the most likely contributors for the creation of business value through improved customer service.

A limitation of the Monte-Carlo approach implemented in MS Excel is the use of pseudo-random numbers by the Excel functions for creating randomised values. These numbers can cause the results of the simulation to be slightly unreliable, but the unreliability will decrease when the number of trials is increased. Therefore a large number of repetitions can be performed to present a solution to that problem.

6.2 RECOMMENDATIONS FOR FURTHER RESEARCH

This section presents the author's recommendations for further research. These recommendations are based on the author's perception of possible improvement or enhancement areas in regard of this thesis.

The next step to test the developed models and to evaluate the conclusions made in this thesis could be either a more advanced and more complex simulation approach or a test of the model based on real-life data.

More advanced simulation approaches include the gaming theory introduced in Section 3.1.2. The use of the gaming theory could include other areas of knowledge into the developed model and therefore enhance the results of the simulation. Gaming theory could also be used to improve the scope of the models by adding additional constructs and factors that could influence the relationships in the three suggested path models. To achieve a more holistic model

the scope could be widened by including other areas that could benefit from the use of ITIL in addition to the customer service area.

A test of the developed models with real-life data could offer an additional test of the hypotheses and the estimates. A test with real-life data could considerably increase the acceptance of the conclusions drawn in this thesis and increase the use of the findings. Therefore the author would highly recommend a survey based quantitative approach as an area of further research regarding the results of this thesis.

In addition it would be very interesting to investigate a quantification of the relationships in the models. Such an investigation could offer an insight into the real value of ITIL in a financial context. Therefore organizations that intend to adopt ITIL would have a clearer understanding of the financial impact that the adoption will have on their organization.

Finally it would be a very interesting approach to develop models for other possible areas that can benefit from the use of ITIL and subsequently develop a holistic model representing the impact of ITIL on the whole organization instead of an isolated view on customer service. A model like that would surely be very interesting for a large audience of researchers and practitioners. In addition it could take the predictability of the outcomes a step further and would allow to predict the impact that an ITIL adoption would have on the organization as a whole on not just on the customer service layer. To achieve such a holistic model it would be necessary to investigate the relationships representing possible benefits of ITIL in areas other than customer service. Subsequently an inclusion of all the models representing the different disciplines would have to be included in one model. Therefore the interactions between the models would have to be explored.

To realise the benchmarking abilities the models would have to be tested against real-life data. The results of that test could provide organizations with the opportunity the measure and evaluate the success of their ITIL implementation in regard of the ITIL impact on customer service against results from other organizations. In addition the monitoring of ongoing service improvement could be enhanced through the provision of a tool to identify the areas for further improvement.

In terms of benchmarking a holistic model would provide a perfect tool for measuring the success of a whole ITIL implementation against the results of other organizations and a tool for measuring the ongoing performance of IT services. The continual improvement efforts that are one of the ITIL principles would benefit from such benchmarking abilities through the provision of a tool to identify the most likely areas for further improvement.

References

Bentley, C. (2001). *Prince2: a practical handbook.* Oxford: Butterworth-Heinemann.

Brush, T.H., Bromiley, P. (1997). What does a small corporate effect mean? A variance components simulation of corporate and business effects. *Strategic Management Journal, 18,* p. 825-835.

Cater-Steel, A., Tan, W-G (2005). Implementation of IT Infrastructure Library (ITIL) in Australia: Progress and success factors. *Proceeding of the IT Governance International Conference*. Auckland, New Zealand.

Cater-Steel, A., Toleman, M., Tan, W-G (2006). Transforming IT Service Management – the ITIL Impact. *Proceedings of the 17th Australasian Conference on Information Systems*. Adelaide, Australia.

Conrad, J.R. (2005). Analyzing the risks of information security investments with monte-carlo simulations. *Workshop on the Economics of Information Security (WEIS)*. Harvard University, 2005.

Debreceny, R.S. (2006). Re-engineering IT Internal Controls: Applying Capability Maturity Models to the Evaluation of IT Controls. *Proceedings of the 39th Hawaii International Conference on System Sciences*. Hawaii.

El Emam, K., Birk, A. Validation the ISO/IEC 15504 Measure of Software Requirements Analysis Process Capability. *IEEE Transactions on Software Engineering, 26*(6), 541 – 566.

Gedam, S.G., Beaudet, S.T. (2000). Monte Carlo Simulation using Excel® spreadsheet for predicting reliability of a complex system. *International Symposium on Product Quality and Integrity*, pp: 88 -93.

Hardy, M.E. (2002). Repeated Simulated Sampling in Excel as a Tool for Teaching Statistics. *JCSC, 17(5)*, pp. 167 – 174.

Henderson, J.C., Venkatraman, N. (1993). Strategic Alignment: Leveraging Information Technology for Transforming Organizations. *IBMSystems Journal, 32*(1), 4-16

Hochstein, A., Tamm, G., Brenner, W. (2005a). Service-Oriented IT Management: Benefit, Cost, and Success Factors. *Proceedings of the Thirteenth European Conference on Information Systems*. Regensburg, Germany.

Hochstein, A., Zarnekow, R., Brenner, W. (2005b). ITIL as common practice reference model for IT service management: formal assessment and implications for practice. *Proceedings of the 2005 IEEE International Conference on e-Technology, e-Commerce and e-Service.* Hong Kong.

Hogan, J.E. (2001). Expected Relationship Value: A Construct, a Methodology for Measurement, and a Modeling Technique. *Industrial Marketing Management, 30*, 339-351.

ICS (2008). "Glossary of Terms" Retrieved 20/06/2008 from http://www.instituteofcustomerservice.com/ExtendedPage.aspx?PageID=59&ID=C

ITGI, OGC (2005). "Aligning COBIT, ITIL and ISO 17799 for Business Benefit: A Management Briefing from the IT Governance Institute and the Office of Government Commerce" Retrieved 18/06/2008, from http://www.isaca.org/Template.cfm?Section=Home&CONTENTID=33947&TEMPLATE=/ContentManagement/ContentDisplay.cfm

ITGI (2006). "Enterprise Value: Governance of IT Investments, The Val IT Framework" Retrieved 24/08/2008, from

http://www.isaca.org/Template.cfm?Section=Home&CONTENTID=35956&TEMPLATE=/ContentManagement/ContentDisplay.cfm

ITGI (2007). "COBIT overview." Retrieved 24/08/2007, 2007, from http://www.isaca.org/Template.cfm?Section=COBIT6&Template=/TaggedPage/TaggedPageDisplay.cfm&TPLID=55&ContentID=7981.

itSMF (2007). "What is a Best Practice?" Retrieved 24/08/2007, 2007, from http://www.itsmf.org/bestpractices/what_is.

Karimi, J., Somers, T.M., Gupta, Y. P. (2001). Impact of Information Technology Management Practices on Customer Service. *Journal of Management Information Systems, 17*(4), 125 – 158.

Keeling, K.B., Pavur, R.J. (2004). Numerical Accuracy Issues in Using Excel for Simulation Studies. *Proceedings on the 36th Conference on Winter Simulation*. Washington D.C., USA.

Klabbers, Jan H. G. (2006). *The Magic Circle: Principles of Gaming & Simulation.* Rotterdam: SensePublishers.

Klingstam, P., Gullander, P. (1999). Overview of Simulation Tools for Computer-aided Production Engineering. *Computer in Industry, 38*, 173 – 186.

Luftman, J., Brier, T. (1999). Achieving and Sustaining Business-IT Alignment. *California Management Review, 42*(1), 109 – 122.

Luftman, J., Lewis, P., & Oldach, S. (1993). Transforming the Enterprise: The Alignment of Business and Information Technology Strategies. *IBM Systems Journal, 32(*1), 198-221.

Metropolis, N. Ulam, S. (1949). The Monte Carlo Method. *J. Amer. Stat. Assoc. 44, 335-341.*

Murray, A., Mohamed, M. S. (2007). The role of ITIL in building the enterprise of the future. *KM World*, *16*(1), 22-23.

OGC (2007a). "ITIL." Retrieved 26/08/2007, 2007, from http://www.ogc.gov.uk/guidance_itil.asp.

OGC (2007b). "Service Management - ITIL." Retrieved 24/08/2007, 2007, from http://www.best-management-practice.com/IT-Service-Management-ITIL/.

OGC (2007c). *Service Strategy*. London: The Stationary Office.

OGC (2007d). *Service Transition*. London: The Stationary Office.

OGC (2007e). *Service Design*. London: The Stationary Office.

OGC (2007f). *Service Operation*. London: The Stationary Office.

OGC (2007g). *Continual Service Improvement*. London: The Stationary Office.

PMI (2004). *A Guide to Project Management Body of Knowledge (PMBOK® Guide)*. Newtown Square (PA): The Project Management Institute.

Potgieter, B. C., Botha, J. H., Lew, C. (2005). Evidence that use of the ITIL framework is effective. *18th Annual Conference of the National Advisory Committee on Computing Qualifications*. Tauranga, New Zealand.

Randers, J (1972). Model validity versus utility of a model. *Lecture at the System Dynamics Summer Institute*. Hannover, Germany.

Ridley, G., Young, J., Caroll, P. (2004). COBIT and its Utilization: A framework from the literature. *37th Hawaii International Conference on System Sciences*. Hawaii.

Robinson, N. (2005). IT excellence starts with governance. *Journal of Investment Compliance, 6*(3), 45 - 49.

Rumelt, R. P. (1991). How much does industry matter?. *Strategic Management Joumal. 12*(3), p. 167-185.

Sallé, M. (2004). IT Service Management and IT Governance: Review, Comparative Analysis and their Impact on Utility Computing. Palo Alto, HP: 1 - 26.

Saltelli, A (2002). Sensitivity Analysis for Importance Assessment. *Risk Analysis, 22(3),* pp. 579 – 590.

SEI (2006). *CMMI for Development, Version 1.2*. Software Engineering Institute, August 2006, URL: http://www.sei.cmu.edu/pub/documents/06.reports/pdf/06tr008.pdf

Schlarman, S. (2007). *Selecting an IT Control Framework. EDPACS, 35*(4), 11 - 17.

Šimková, E., Basl, J. (2006). Business value of IT. *14th annual conference System Integration 2006*. Prague, Czech Republic.

Tallon, P.P., Kraemer, K.L., Gurbaxani, V. (2000). Executives' Perceptions of the Business Value of Information Technology: A Process-Oriented Approach. *Journal of Management Information Systems, 16(4),* pp. 145-173.

Vickery, S.K., Jayaram, J., Droge, C., Calantone, R. (2003). The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships. *Journal of Operations Management 21,* 523-539.

Wagner, H. (2006). Managing the Impact of IT on Firm Success: The Link between the Resource-Based View and the IT Infrastructure Library. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences*. Hawaii.

Appendices

Appendix A: Source Code of Macro

This appendix contains the source code of the macro developed in MS Excel in order to perform a large number of repetitions of the simulation.

```
Sub Simulation1()
'
' Simulation1 Macro
' Repetition of Simulation
'
'
        For N = 1 To 10000
        Calculate
        Range("J2:J2").Select
        Selection.Copy
        ActiveCell(N, 2).Select
        Selection.PasteSpecial Paste:=xlValues, Operation:=xlNone,
        SkipBlanks:=False, Transpose:=False
        Next N

End Sub
```

Appendix B: Full Distribution Results for the Fully Mediated Model

This appendix contains the full results of the distribution of the fully mediated model with all estimates set on medium. This setting represents the most likely settings for the fully mediated model.

Table B.1: Full Distribution Results for the Fully Mediated Model

Value	*Frequency*	*Value*	*Frequency*	*Value*	*Frequency*
4259	0	4423	10	4587	25
4260	0	4424	11	4588	26
4261	0	4425	8	4589	20
4262	0	4426	14	4590	22
4263	0	4427	14	4591	15
4264	0	4428	13	4592	22
4265	0	4429	16	4593	21
4266	0	4430	22	4594	15
4267	0	4431	12	4595	15
4268	0	4432	19	4596	20
4269	0	4433	14	4597	12
4270	0	4434	17	4598	11
4271	0	4435	11	4599	3
4272	0	4436	17	4600	15
4273	0	4437	12	4601	18
4274	0	4438	18	4602	15
4275	0	4439	17	4603	10
4276	0	4440	23	4604	18
4277	0	4441	16	4605	17
4278	0	4442	22	4606	9
4279	0	4443	29	4607	7
4280	0	4444	22	4608	11
4281	0	4445	18	4609	14
4282	0	4446	31	4610	13
4283	0	4447	27	4611	8
4284	0	4448	30	4612	10
4285	0	4449	22	4613	11
4286	0	4450	31	4614	5
4287	0	4451	40	4615	7
4288	0	4452	29	4616	8
4289	0	4453	30	4617	6
4290	0	4454	33	4618	7
4291	0	4455	39	4619	4
4292	0	4456	32	4620	7

4293	0	4457	40	4621	6
4294	0	4458	40	4622	3
4295	0	4459	31	4623	3
4296	0	4460	44	4624	7
4297	0	4461	38	4625	4
4298	0	4462	44	4626	2
4299	0	4463	50	4627	6
4300	0	4464	40	4628	5
4301	0	4465	39	4629	3
4302	0	4466	45	4630	2
4303	0	4467	39	4631	2
4304	0	4468	54	4632	4
4305	0	4469	65	4633	2
4306	0	4470	49	4634	2
4307	0	4471	46	4635	4
4308	0	4472	60	4636	3
4309	0	4473	52	4637	0
4310	0	4474	49	4638	1
4311	0	4475	73	4639	0
4312	0	4476	50	4640	2
4313	0	4477	64	4641	1
4314	0	4478	62	4642	4
4315	0	4479	71	4643	1
4316	0	4480	66	4644	1
4317	0	4481	61	4645	5
4318	0	4482	75	4646	1
4319	0	4483	59	4647	0
4320	0	4484	72	4648	1
4321	0	4485	72	4649	0
4322	0	4486	72	4650	1
4323	0	4487	97	4651	0
4324	0	4488	69	4652	1
4325	0	4489	92	4653	0
4326	0	4490	90	4654	1
4327	0	4491	72	4655	0
4328	0	4492	62	4656	0
4329	0	4493	73	4657	0
4330	0	4494	78	4658	0
4331	0	4495	90	4659	0
4332	0	4496	92	4660	0
4333	0	4497	60	4661	0
4334	0	4498	106	4662	0
4335	0	4499	88	4663	0
4336	0	4500	78	4664	1
4337	0	4501	88	4665	1
4338	0	4502	95	4666	0

4339	0	4503	86	4667	0
4340	0	4504	97	4668	0
4341	0	4505	74	4669	0
4342	0	4506	102	4670	1
4343	0	4507	109	4671	0
4344	0	4508	94	4672	0
4345	0	4509	99	4673	1
4346	0	4510	87	4674	0
4347	1	4511	84	4675	1
4348	0	4512	93	4676	0
4349	0	4513	105	4677	0
4350	0	4514	76	4678	0
4351	0	4515	95	4679	0
4352	1	4516	82	4680	0
4353	0	4517	94	4681	0
4354	0	4518	84	4682	0
4355	1	4519	100	4683	0
4356	0	4520	97	4684	0
4357	0	4521	89	4685	1
4358	0	4522	108	4686	0
4359	0	4523	73	4687	0
4360	0	4524	84	4688	0
4361	0	4525	92	4689	0
4362	0	4526	94	4690	0
4363	1	4527	83	4691	0
4364	0	4528	78	4692	0
4365	0	4529	79	4693	0
4366	0	4530	79	4694	0
4367	1	4531	82	4695	0
4368	0	4532	89	4696	0
4369	0	4533	77	4697	0
4370	0	4534	104	4698	0
4371	1	4535	79	4699	0
4372	0	4536	88	4700	0
4373	1	4537	76	4701	0
4374	1	4538	77	4702	0
4375	2	4539	71	4703	0
4376	1	4540	82	4704	0
4377	1	4541	82	4705	0
4378	4	4542	60	4706	0
4379	1	4543	88	4707	0
4380	1	4544	65	4708	0
4381	1	4545	65	4709	1
4382	0	4546	77	4710	0
4383	1	4547	61	4711	0
4384	0	4548	55	4712	0

4385	2	4549	59	4713	0
4386	2	4550	73	4714	0
4387	1	4551	63	4715	0
4388	4	4552	76	4716	0
4389	3	4553	55	4717	0
4390	2	4554	63	4718	0
4391	2	4555	60	4719	0
4392	1	4556	54	4720	0
4393	4	4557	54	4721	0
4394	3	4558	58	4722	0
4395	3	4559	42	4723	0
4396	0	4560	52	4724	0
4397	0	4561	53	4725	0
4398	1	4562	50	4726	0
4399	4	4563	68	4727	0
4400	3	4564	46	4728	0
4401	2	4565	50	4729	0
4402	2	4566	38	4730	0
4403	8	4567	55	4731	0
4404	3	4568	49	4732	0
4405	3	4569	33	4733	0
4406	4	4570	37	4734	0
4407	9	4571	47	4735	0
4408	7	4572	38	4736	0
4409	4	4573	40	4737	0
4410	4	4574	37	4738	0
4411	4	4575	36	4739	0
4412	3	4576	35	4740	0
4413	4	4577	38	4741	0
4414	5	4578	31	4742	0
4415	7	4579	44	4743	0
4416	4	4580	30	4744	0
4417	3	4581	27	4745	0
4418	10	4582	23	4746	0
4419	16	4583	22	4747	0
4420	11	4584	36	4748	0
4421	7	4585	22	4749	0
4422	4	4586	30	Larger	0

Appendix C: Full Distribution Results for the Partially Mediated Model

This appendix contains the full results of the distribution of the partially mediated model with all estimates set on medium. This setting represents the most likely settings for the partially mediated model.

Table C.1: Full Distribution Results for the Partially Mediated Model

Value	*Frequency*	*Value*	*Frequency*	*Value*	*Frequency*
3749	0	3913	39	4077	3
3750	0	3914	39	4078	6
3751	0	3915	48	4079	7
3752	0	3916	37	4080	1
3753	0	3917	30	4081	2
3754	0	3918	45	4082	2
3755	0	3919	40	4083	4
3756	0	3920	44	4084	6
3757	0	3921	41	4085	4
3758	0	3922	51	4086	3
3759	0	3923	38	4087	3
3760	0	3924	48	4088	7
3761	0	3925	54	4089	2
3762	0	3926	48	4090	4
3763	0	3927	56	4091	4
3764	0	3928	43	4092	0
3765	0	3929	51	4093	1
3766	0	3930	55	4094	1
3767	0	3931	53	4095	3
3768	0	3932	57	4096	1
3769	0	3933	57	4097	0
3770	0	3934	51	4098	2
3771	0	3935	60	4099	2
3772	0	3936	75	4100	2
3773	0	3937	63	4101	3
3774	0	3938	55	4102	1
3775	0	3939	59	4103	2
3776	0	3940	69	4104	3
3777	0	3941	61	4105	2
3778	0	3942	71	4106	1
3779	0	3943	66	4107	1
3780	0	3944	78	4108	0
3781	0	3945	83	4109	0
3782	0	3946	64	4110	1
3783	0	3947	68	4111	1

3784	0	3948	75	4112	0
3785	0	3949	77	4113	1
3786	0	3950	88	4114	1
3787	0	3951	83	4115	1
3788	0	3952	79	4116	1
3789	0	3953	96	4117	0
3790	0	3954	85	4118	1
3791	0	3955	77	4119	0
3792	0	3956	77	4120	1
3793	0	3957	83	4121	0
3794	0	3958	79	4122	0
3795	0	3959	92	4123	0
3796	0	3960	55	4124	0
3797	0	3961	82	4125	0
3798	0	3962	71	4126	0
3799	0	3963	93	4127	0
3800	0	3964	73	4128	0
3801	0	3965	89	4129	1
3802	0	3966	85	4130	1
3803	0	3967	107	4131	0
3804	1	3968	91	4132	0
3805	0	3969	84	4133	0
3806	0	3970	83	4134	0
3807	0	3971	98	4135	0
3808	0	3972	121	4136	0
3809	0	3973	113	4137	0
3810	0	3974	113	4138	0
3811	0	3975	101	4139	0
3812	1	3976	72	4140	0
3813	0	3977	107	4141	0
3814	0	3978	77	4142	0
3815	0	3979	81	4143	0
3816	0	3980	104	4144	0
3817	1	3981	88	4145	0
3818	0	3982	113	4146	0
3819	0	3983	92	4147	0
3820	0	3984	89	4148	0
3821	0	3985	97	4149	0
3822	0	3986	101	4150	0
3823	0	3987	83	4151	0
3824	0	3988	91	4152	0
3825	0	3989	97	4153	0
3826	0	3990	72	4154	0
3827	0	3991	101	4155	0
3828	0	3992	82	4156	0
3829	0	3993	90	4157	0

3830	0	3994	73	4158	0
3831	0	3995	98	4159	0
3832	0	3996	88	4160	0
3833	3	3997	88	4161	0
3834	1	3998	82	4162	0
3835	1	3999	73	4163	0
3836	0	4000	73	4164	0
3837	1	4001	79	4165	0
3838	1	4002	82	4166	0
3839	0	4003	66	4167	0
3840	0	4004	62	4168	0
3841	1	4005	66	4169	0
3842	0	4006	55	4170	0
3843	1	4007	70	4171	0
3844	0	4008	69	4172	0
3845	0	4009	70	4173	0
3846	2	4010	61	4174	0
3847	1	4011	59	4175	0
3848	1	4012	70	4176	0
3849	0	4013	58	4177	0
3850	1	4014	56	4178	0
3851	0	4015	67	4179	0
3852	2	4016	52	4180	0
3853	0	4017	51	4181	0
3854	2	4018	61	4182	0
3855	1	4019	56	4183	0
3856	3	4020	56	4184	0
3857	2	4021	66	4185	0
3858	2	4022	52	4186	0
3859	1	4023	38	4187	0
3860	1	4024	39	4188	0
3861	6	4025	52	4189	0
3862	0	4026	39	4190	0
3863	1	4027	45	4191	0
3864	1	4028	45	4192	0
3865	4	4029	31	4193	0
3866	1	4030	36	4194	0
3867	5	4031	44	4195	0
3868	4	4032	31	4196	0
3869	3	4033	40	4197	0
3870	6	4034	35	4198	0
3871	5	4035	30	4199	0
3872	5	4036	34	4200	0
3873	4	4037	36	4201	0
3874	6	4038	27	4202	0
3875	5	4039	34	4203	0

3876	6	4040	34	4204	0
3877	6	4041	33	4205	0
3878	6	4042	15	4206	0
3879	3	4043	23	4207	0
3880	11	4044	28	4208	0
3881	7	4045	20	4209	0
3882	3	4046	30	4210	0
3883	13	4047	20	4211	0
3884	11	4048	21	4212	0
3885	3	4049	23	4213	0
3886	12	4050	20	4214	0
3887	13	4051	19	4215	0
3888	14	4052	15	4216	0
3889	20	4053	20	4217	0
3890	10	4054	30	4218	0
3891	18	4055	19	4219	0
3892	14	4056	25	4220	0
3893	17	4057	13	4221	0
3894	14	4058	15	4222	0
3895	19	4059	15	4223	0
3896	19	4060	11	4224	0
3897	21	4061	13	4225	0
3898	18	4062	12	4226	0
3899	29	4063	10	4227	0
3900	18	4064	12	4228	0
3901	20	4065	9	4229	0
3902	14	4066	12	4230	0
3903	25	4067	9	4231	0
3904	27	4068	13	4232	0
3905	28	4069	5	4233	0
3906	33	4070	9	4234	0
3907	23	4071	6	4235	0
3908	28	4072	9	4236	0
3909	38	4073	2	4237	0
3910	28	4074	2	4238	0
3911	34	4075	9	4239	0
3912	32	4076	5	larger	0

Appendix D: Full Distribution Results for the Unmediated Model

This appendix contains the full results of the distribution of the unmediated model with all estimates set on medium. This setting represents the most likely settings for the unmediated model.

Table C.2: Full Distribution Results for the Unmediated Model

Value	*Frequency*	*Value*	*Frequency*	*Value*	*Frequency*
4699	0	4863	17	5027	24
4700	0	4864	16	5028	19
4701	0	4865	23	5029	20
4702	0	4866	28	5030	27
4703	0	4867	12	5031	15
4704	0	4868	18	5032	22
4705	0	4869	14	5033	19
4706	0	4870	16	5034	10
4707	0	4871	18	5035	17
4708	0	4872	27	5036	14
4709	0	4873	30	5037	15
4710	0	4874	25	5038	12
4711	0	4875	27	5039	19
4712	0	4876	23	5040	13
4713	0	4877	25	5041	29
4714	0	4878	30	5042	14
4715	0	4879	29	5043	13
4716	0	4880	22	5044	13
4717	0	4881	34	5045	8
4718	0	4882	23	5046	18
4719	0	4883	20	5047	16
4720	0	4884	38	5048	10
4721	0	4885	37	5049	9
4722	0	4886	38	5050	6
4723	0	4887	39	5051	2
4724	0	4888	22	5052	12
4725	0	4889	46	5053	7
4726	0	4890	46	5054	5
4727	0	4891	34	5055	4
4728	0	4892	41	5056	8
4729	0	4893	41	5057	6
4730	0	4894	35	5058	3
4731	0	4895	52	5059	5
4732	0	4896	40	5060	6
4733	0	4897	46	5061	6

4734	0	4898	54	5062	5
4735	0	4899	35	5063	4
4736	0	4900	41	5064	5
4737	0	4901	47	5065	5
4738	0	4902	49	5066	3
4739	0	4903	43	5067	3
4740	0	4904	49	5068	1
4741	0	4905	65	5069	5
4742	0	4906	62	5070	4
4743	0	4907	57	5071	0
4744	0	4908	55	5072	0
4745	0	4909	42	5073	0
4746	0	4910	63	5074	4
4747	0	4911	56	5075	6
4748	0	4912	62	5076	2
4749	0	4913	57	5077	2
4750	0	4914	66	5078	3
4751	0	4915	51	5079	2
4752	0	4916	63	5080	1
4753	0	4917	69	5081	1
4754	0	4918	81	5082	1
4755	0	4919	77	5083	3
4756	0	4920	68	5084	3
4757	0	4921	79	5085	2
4758	0	4922	79	5086	2
4759	0	4923	78	5087	3
4760	0	4924	73	5088	2
4761	0	4925	78	5089	0
4762	0	4926	94	5090	0
4763	0	4927	63	5091	1
4764	0	4928	86	5092	2
4765	0	4929	80	5093	0
4766	0	4930	77	5094	0
4767	0	4931	82	5095	0
4768	0	4932	66	5096	1
4769	1	4933	78	5097	0
4770	0	4934	65	5098	1
4771	0	4935	82	5099	0
4772	0	4936	67	5100	0
4773	0	4937	74	5101	0
4774	0	4938	81	5102	2
4775	0	4939	85	5103	0
4776	0	4940	97	5104	0
4777	0	4941	75	5105	0
4778	2	4942	80	5106	0
4779	1	4943	74	5107	1

4780	0	4944	83	5108	0
4781	0	4945	97	5109	0
4782	0	4946	73	5110	0
4783	0	4947	99	5111	0
4784	0	4948	84	5112	1
4785	0	4949	92	5113	0
4786	0	4950	94	5114	0
4787	0	4951	81	5115	0
4788	0	4952	94	5116	0
4789	0	4953	89	5117	0
4790	0	4954	80	5118	2
4791	0	4955	86	5119	0
4792	0	4956	78	5120	0
4793	0	4957	94	5121	0
4794	0	4958	79	5122	0
4795	0	4959	78	5123	0
4796	2	4960	72	5124	0
4797	2	4961	82	5125	0
4798	2	4962	78	5126	0
4799	1	4963	73	5127	0
4800	0	4964	81	5128	0
4801	0	4965	74	5129	0
4802	0	4966	90	5130	0
4803	0	4967	65	5131	0
4804	1	4968	69	5132	0
4805	1	4969	96	5133	0
4806	0	4970	85	5134	0
4807	0	4971	58	5135	0
4808	1	4972	73	5136	0
4809	2	4973	73	5137	0
4810	3	4974	61	5138	0
4811	1	4975	63	5139	0
4812	1	4976	85	5140	0
4813	2	4977	75	5141	0
4814	1	4978	74	5142	0
4815	0	4979	72	5143	0
4816	1	4980	73	5144	0
4817	3	4981	58	5145	0
4818	2	4982	70	5146	0
4819	3	4983	64	5147	0
4820	3	4984	56	5148	0
4821	1	4985	78	5149	0
4822	1	4986	47	5150	0
4823	2	4987	53	5151	0
4824	4	4988	58	5152	0
4825	5	4989	52	5153	0

4826	4	4990	58	5154	0
4827	3	4991	62	5155	0
4828	5	4992	59	5156	0
4829	5	4993	55	5157	0
4830	5	4994	58	5158	0
4831	2	4995	55	5159	0
4832	4	4996	52	5160	0
4833	6	4997	50	5161	0
4834	6	4998	44	5162	0
4835	4	4999	56	5163	0
4836	2	5000	41	5164	0
4837	7	5001	60	5165	0
4838	9	5002	41	5166	0
4839	8	5003	49	5167	0
4840	7	5004	52	5168	0
4841	6	5005	44	5169	0
4842	8	5006	41	5170	0
4843	5	5007	35	5171	0
4844	6	5008	38	5172	0
4845	6	5009	42	5173	0
4846	7	5010	42	5174	0
4847	9	5011	46	5175	0
4848	8	5012	40	5176	0
4849	3	5013	37	5177	0
4850	12	5014	32	5178	0
4851	3	5015	38	5179	0
4852	7	5016	29	5180	0
4853	7	5017	32	5181	0
4854	6	5018	31	5182	0
4855	14	5019	26	5183	0
4856	12	5020	28	5184	0
4857	18	5021	25	5185	0
4858	8	5022	23	5186	0
4859	11	5023	23	5187	0
4860	12	5024	29	5188	0
4861	17	5025	27	5189	0
4862	14	5026	20	larger	0