



**UNIVERSIDADE DE LISBOA
INSTITUTO SUPERIOR TÉCNICO**

**Enhancing multicriteria resource allocation modelling with
structuring and negotiation tools to improve decision-making in
auditing contexts**

Vivian Vivas

Supervisor: Doctor Mónica Duarte Correia de Oliveira

**Thesis approved in public session to obtain the PhD Degree in
Engineering and Management**

Jury final classification: Pass with Distinction

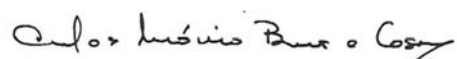
2020

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Lisboa, 22 de junho de 2020

O Presidente do Júri

Homologo





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2020

Abstract

Context: Multicriteria resource allocation is widely recognized as essential in the decision support and operational research fields for contexts in which an individual or group need to allocate scarce resources to competing projects that entail multiple benefits, risks and costs. Nevertheless, few studies report the adoption of multicriteria resource allocation models (MRAMs) in real settings and provide guidelines and tools to help researchers structuring and applying these models in practice. Similar to other public auditing organizations, the Comptroller General of the Union (CGU) in Brazil needs to frequently decide on which audit projects to be carried out by their teams while taking into consideration of budgetary, logistical and human resources constraints, as well as while considering the multiple differences in opinion and conflicts of interest that arise in the process of negotiation about which audit project to select. Accordingly, there is an opportunity to develop methods and tools to help structuring MRAMs, to help modelling the different views from multiple stakeholders and to help negotiation processes, with these methods being of high interest to CGU.

Objectives: With the overall objective of providing multicriteria tools to support audit organizations in allocating resources to their audit projects and to help CGU. Specifically, there is an aim to develop methods and tools to help structuring MRAMs, to assist the development of MRAMs in negotiation contexts, and to help the CGU to move towards the use of these methods with a decision support system (DSS).

Methods: Several studies were conducted in this thesis towards the development of a framework for structuring MRAMs, the implementation and test of the structuring framework, the development of instruments/methods to support informed negotiation, and the proposal of an architectural model of a DSS to enable the implementation and use of these methods at CGU. Based on sound theoretical methods and participatory processes embedded within socio-technical approaches, the studies were inspired and applied to the CGU context, namely into the elaboration of Operation Plan in the Comptroller Department of CGU. Feedback regarding the approach was collected from participants.

Results: The methods and tools presented in this thesis were implemented based on cases, which required the involvement of stakeholders in different studies, such as on structuring and building of MRAMs or on participation in negotiation processes. Regarding CGU feedback, the study brought an expectation to improve the internal decision-making processes and there is a real intention of the

organization to use these developed instruments. Also, the participants provided positive feedback about the tested methods.

Discussion: The developed methods addressed the current challenges of integrating portfolio analysis within negotiation and have the potential to improve CGU's decision-making resource allocation processes. Future research should be performed in order to extend and apply the methodology to other auditing contexts and beyond the audit context.

Keywords: Multicriteria Decision Analysis, Portfolio Decision Analysis, Auditing, Negotiation, Decision Support System.

Resumo

Contexto: A avaliação multicritério para afetação de recursos é amplamente reconhecida como essencial nas áreas de apoio à decisão e pesquisa operacional, em contextos em que indivíduos ou um grupo de decisores precisam alocar seus escassos recursos em projetos concorrentes e que envolvam múltiplos benefícios, riscos e custos. No entanto, poucos estudos relatam a adoção desses modelos multicritério de afetação de recursos (MMARs) em ambiente real e fornecem diretrizes e ferramentas para apoiar os pesquisadores a estruturar e aplicar esses modelos na prática. De forma semelhante a outras organizações públicas de auditoria, a Controladoria-Geral da União (CGU) no Brasil lida com frequência com decisões acerca de quais projetos de auditoria serão executados por suas equipes, levando-se em consideração as restrições orçamentárias, logísticas e de recursos humanos, além de se considerar as diferenças de opinião e conflitos de interesse que surgem ao longo do processo de negociação sobre quais projetos selecionar. Dessa forma, existe uma oportunidade de desenvolver métodos e ferramentas para apoiar na estruturação de MMARs, para modelar as diferentes visões de vários *stakeholders* e para ajudar nos processos de negociação, sendo esses métodos de alto interesse para a CGU.

Objetivos: O objetivo geral desta tese é desenvolver ferramentas multicritério para apoiar as organizações de auditoria na afetação de recursos em seus projetos de auditoria, bem como apoiar a CGU. Especificamente, há objetivos de criar métodos e ferramentas para ajudar a estruturar MMARs, auxiliar a construção de MMARs em contextos de negociação e ajudar a CGU a avançar no uso desses métodos apoiada por um sistema de suporte à decisão (DSS).

Métodos: Vários estudos foram conduzidos nesta tese para o desenvolvimento de um *framework* para a estruturação de MMARs, para a implementação e teste deste *framework* de estruturação, para o desenvolvimento de instrumentos / métodos para apoiar a negociação informada e na proposta de um modelo de arquitetura de um DSS para possibilitar a implementação e o uso desses métodos na CGU. Com base em métodos robustos e em processos participativos combinados em abordagens sociotécnicas, os estudos foram inspirados e aplicados ao contexto da CGU, nomeadamente na elaboração do Plano Operacional do Departamento de Auditoria da CGU. Feedback sobre os métodos foi coletado dos participantes.

Resultados: Os métodos e ferramentas desenvolvidos nesta tese foram implementados em casos que exigiram o envolvimento de *stakeholders* em diferentes estudos, tanto na estruturação quanto na construção e validação dos MMARs, bem como na participação nos processos de negociação. Em relação ao feedback da CGU, o estudo trouxe uma expectativa de melhoria dos processos internos de

tomada de decisão e existe uma intenção real da organização de usar esses instrumentos desenvolvidos. Além disso, os participantes reportaram uma experiência positiva sobre os métodos testados.

Discussão: Os métodos desenvolvidos responderam aos desafios atuais de se integrar a análise de portfólios com a negociação e tem potencial para melhoria dos processos de afetação de recursos para tomada de decisão da CGU. Pesquisas futuras podem ser realizadas para estender e aplicar a metodologia a outros contextos além da auditoria.

Palavras-chave: Análise de Decisão Multicritério, Análise de Decisão de Portfólio, Auditoria, Negociação, Sistema de Suporte à Decisão.

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List of Abbreviations

AAA	Annual Audit of Accounts
AFT	Alternative-focused Thinking
BATNA	Best Alternative to a Negotiated Agreement
CGPLAM	<i>Coordenação-geral de Planejamento, Avaliação e Monitoramento</i> (in Portuguese)
CGU	Comptroller General of the Union
DSS	Decision Support System
EGPE	Evaluation of the Government Programs Execution
IFI	Inspection in Federal Institutions
MCDA	Multicriteria Decision Analysis
MRAM	Multicriteria Resource Allocation Model
MRE	Management Results Evaluation
PDA	Portfolio Decision Analysis
RPM	Robust Portfolio Modelling
SCA	Strategic Choice Approach
SFC	<i>Secretaria Federal de Controle Interno</i> (in Portuguese)
SNT	Single Negotiation Text
SSM	Soft Systems Methodology
VCSD	Verification of Complaints and Social Demands
VFT	Value-focused Thinking

Chapter 1 INTRODUCTION

Decision-makers in all organizations, including in public auditing ones, are constantly dealing with scarce resources to be employed in their projects in order to fulfill their institutional missions. Under the presence of a limited budget and of other relevant constraints, they must choose the set of projects to be executed with the available budget, considering not only costs but also a range of benefits and risks. Multicriteria based modelling approaches for resource allocation have been created and employed in the operational research and decision sciences literature to assist managers in charge of allocating resources in light of attaining multiple objectives (Almeida et al., 2014; Bana e Costa et al., 2006; Fernandez and Olmedo, 2013). However, an extensive and effective adoption and use of these models in real contexts has not been observed, there being a need to develop practical tools to enable its use. In fact, other challenges can be pointed out in this context, such as what to consider in those models, how to support the decision-makers that no have a complete understanding of all the consequences of every project, how to support the decision-makers that have divergences in opinions and not totally agree about the expected benefits, risks and costs of each project (Montibeller et al., 2009).

These challenges have been perceived as relevant by the Comptroller General of the Union (CGU), in Brazil, the Brazilian government ministry responsible for auditing public accounts. Specifically, CGU decision-makers recognize the need of improving processes and tools to help: to plan its activities on a common and transparent basis, in which audit projects to be performed by its teams should be selected through a solid and structured process that involves all the relevant stakeholders; to resolve conflicts or divergences in a structured way when they appear in the negotiation process that occurs in the selection of auditing projects; and, to improve existing corporate information systems so that they enable a structured and well-informed negotiation process. Hence, CGU gave support to this thesis and made it possible to develop research with scientific and practical relevant that is inspired and implemented to a real organization. Critical to development and implementation of methods within multicriteria resource allocation is the need to involve relevant CGU stakeholders through specifically designed participatory processes.

Therefore, this thesis aims to explore these challenges and gaps identified in the literature above described, particularly related to audit organizations. Integration of multicriteria decision analysis (MCDA) literature with negotiation literature will also be explored, to face situations of conflict of

interest or divergence of opinion. In this introductory chapter, we will present the context within which the thesis was carried out, and set the thesis general objective within the CGU and the operational research and decision sciences context. The decision problematic and the challenges in the literature, as well as the specific objectives and research questions are detailed. Finally, the contribution of each study developed in the thesis is presented, as well as an integrated view provided.

1.1. CGU Context

In Brazil, many government programs are applied throughout its whole territory, although programs' features need to consider the peculiarities of each local region. Many debates are still held in the government regarding the size of the State, about decentralization and devolution of power, as well as about the best economic policies to improve the country. However, despite the recent fiscal and economic crisis, there has been little discussion about the operational nature of changes in the public administration, although these changes are decisive for an effective and successful implementation of public policies. In fact, it is broadly recognised that the Brazilian Public Administration will have to improve, quickly and substantially its capacity planning and control of projects and investments in many sectors, including infrastructure, security, health and education. The current little signs of resumption of economic growth with consequent positive impacts on public revenues will not change the restrictions on public spending to multiple competing programs. In this context, and similar to other countries, improving allocative efficiency of resources is an essential factor to ensure quality of services provided by Brazil to its population.

In this sense, the public spending of federal funds is audited by the CGU. The CGU is the federal government ministry responsible for supporting the Brazilian government regarding matters within the executive branch, whether relating to the protection of public property and increasing the transparency of management. Its mission is to promote the improvement and transparency of public management, the prevention and the fight against corruption, with social participation, through the evaluation and control of public policies and the quality of spending. These attributions already show an environment with multiple objectives, among which are: producing strategic information to support the decision-making of the federal government; contribute to the delivery of effective and quality public policies to the citizen; expand social participation in the control of public policies; face corruption; and foster innovation and reduce bureaucracy in public management.

In a time when the country is still struggling with the consequences of a recent serious economic crisis, CGU has a key role in promoting transparency and accountability in public spending. Similar to public sector organizations in other countries, CGU's activities are oriented to the satisfaction of public interests and depend on the ability to plan, to elaborate and make decisions effectively, and to control the implementation of such decisions (Balabonienė and Večerskienė, 2015). As a public auditing organization, the activities of the CGU integrate actions of corruption prevention, fraud deterrence, public accounting, comptroller, ombudsman activities and increased transparency in management. To fulfill your duties, CGU is structured in five finalistic departments, which act in an articulated way, in actions organized among themselves: Secretariat of Transparency and Prevention of Corruption (*Secretaria de Transparência e Prevenção da Corrupção – STPC* in Portuguese), Internal Control Federal Office (*Secretaria Federal de Controle Interno – SFC* in Portuguese), Corrections Internal Affairs Office (*Corregedoria-Geral da União – CRG* in Portuguese), Federal Ombudsman's Office (*Ouvidoria-Geral da União – OGU* in Portuguese) and Anti-Corruption Secretariat (*Secretaria de Combate à Corrupção – SCC* in Portuguese). Of these, it is worth mentioning that SFC plays the central function in the internal control system of the Federal Executive Branch in Brazil and supervises and evaluates the execution of government programs, including decentralized actions to public and private entities made with resources coming from the Union budgets, performs audits and evaluates the results of the federal public administrators management, clears denunciations and representations, controls credit operations, and also performs activities in support of external control.

Currently, SFC makes use of Tactical and Operational Plans as planning instruments to the execution of its tasks. The Tactical Plan contains the guidelines for the annual operation of the SFC strategies through the definition of priority themes (public policy/management) considered relevant to the board of directors. In turn, the Operational Plan contains the proposal of audit projects (control actions) to be performed by the audit teams throughout the year, in accordance with the guidelines established in the Tactical Plan, which contributes to the achievement of mission, vision and strategic objectives in the following areas: results, internal processes, people and infrastructure. It is thus necessary to define which audit projects will be executed within the available resources and that will bring the greatest expected benefit and risk in multiple dimensions, which means, with multiple objectives to take into account in the evaluation and the selection of audit projects. Thus, CGU is aware of the need and space to improve the audit project selection process, and the involvement of CGU stakeholders in this process deemed as essential by CGU.

1.2. Challenges in the literature to address the decision problematic

The multicriteria resource allocation problem above described is characterized by the selection (integrating the portfolio) of attractive audit projects under multiple objectives to be funded in the presence of a limited budget and of other relevant constraints (Phillips and Bana e Costa, 2007). The prioritization and/or selection of options aims at generating portfolios of audit projects – which entail multiple benefits, costs and uncertainties – that offer the best overall value for a given budget. Clearly, the analyses of portfolios will depend on how the organization's decision-makers values (Fasolo and Bana e Costa, 2014; Keeney, 1992), on the audit projects' benefits and risks, as well as on the costs required by those projects and by context constraints. As these benefits are usually multi-dimensional (e.g., losses recovery, strategic fit, social responsibility, safety etc.), this is a multicriteria problem (Belton and Stewart, 2002).

Some multicriteria models for resource allocation have been reported in literature to support decision-makers in managing portfolios, taking into account of costs, benefits and risks (Liesiö et al., 2007; Lourenço et al., 2012; Oliveira et al., 2012; Phillips and Bana e Costa, 2007). However, the practical use of such models is not frequent (Bana e Costa et al., 2014; Oliveira et al., 2012), and there is little indication in the decision sciences and operational research literature on how to structure such type of problems in an integrated and organized manner (Montibeller et al., 2009). Proper structuring is required for building models that can effectively assist decision-makers (Bana e Costa and Beinat, 2005; Belton and Stewart, 2010; Marttunen et al., 2017). Therefore, to build useful multicriteria resource allocation models it is necessary to get all the information pertaining on models, which means defining the organizational areas, audit units, project options, costs, measurement criteria of benefits, risks, synergies and interdependencies between projects and other necessary factors (Friend and Hickling, 2005; Keeney, 1992; Montibeller et al., 2009), as well as to understand who should participate in model construction and whom the model is expected to assist.

In auditing contexts although there are some studies presenting multicriteria models (Krüger and Hattingh, 2006) for planning and scheduling of audit work (for a review, see Mohamed 2015), up to our knowledge there is no work on how to structure and develop multicriteria resource allocation models (MRAMs) to assist auditing decisions by literature in the area. It is thus relevant to develop a framework to support structuring MRAMs in an audit context that can address this gap. The framework should not only based on sound theoretical methods but also rely on participatory processes. More

than just defining which tools and techniques are most appropriate to tackle the problem that is being faced, it is necessary to count on the effective participation of those involved, as well as dealing with the different perspectives in order to seek the best possible convergence solution (Fasth et al., 2016). Thus, a socio-technical process needs to be designed to apply the framework and to present results from its application in a real-world situation (Bana e Costa et al., 2014).

CGU has multiple situations related to the allocation of resources in which the use of multicriteria resource allocation models can be useful. This is the case, for instance, of the elaboration processes of planning instruments for SFC, materialized in the Tactical and Operational Plans. These plans should be built on multiple objectives and have criteria to define which projects should be prioritized and implemented throughout the year. While in the Tactical Plan are presented the strategic lines of action that must be faced by the organizational units, the Operational Plan needs to provide an indication about how to materialize and operationalize these tactical guidelines. CGU has many audit projects to perform at different levels, but faces human, logistical and financial constraints, and needs to know which audit projects bring the most benefits to achieving the organization's strategic objectives.

Further work is also needed to address other contexts, especially those that involve conflicts of interest or divergent views. So, the different objectives to be achieved according to each stakeholder group should be considered in MRAMs and, under the presence of conflicts of interest, adaptations to the models and application of complementary negotiation tools may be necessary. In these cases, it may be useful to apply conflicts dissolution modelling techniques to have an understanding for possible win-win solutions, which are often used for evaluation models but can be adapted to the structuring context (Bana e Costa, 2001; Bana e Costa et al., 2001; Edwards et al., 2007; Fasth et al., 2016).

A study that seeks the development of decision support models and tools and assist negotiation in the context of auditing can contribute both at the academic and organizational levels. In the knowledge area of multicriteria decision analysis, there are not many studies that integrate portfolio models with negotiation techniques. At the organizational level, it can contribute to the improvement of internal processes, transparency and sound justification of decisions. In addition, all development should be guided by a participatory process, with the adoption of a socio-technical process.

Finally, heading towards the literature to support the development of support systems in the context of resources allocation decisions, and seeking a starting point for integration with the negotiation context, we note that there is still much to contribute to the literature in terms of using

negotiation support systems aided by multicriteria analysis (Bellucci and Zeleznikow, 1998; Górecka et al., 2016).

Therefore, based on the existing groundwork on multicriteria portfolio decision analysis and negotiation literature and the research gaps identified in the literature, this thesis intends to develop a socio-technical multicriteria approach that can enhance multicriteria resource allocation processes with negotiation tools to assist decision-makers in the selection of audit projects, and that can be converted in an actionable tool, like in a decision support system (DSS).

1.3. Objectives and Research Questions

Thus, addressing the challenges of the literature and the challenges in the context of the CGU, the main aim of this thesis is to develop methods to support audit organizations in project selection and resource allocation decisions. The following are the four research questions and their associated objectives that, taken together, help to achieve the main aim of the thesis:

- **RQ1 - How to help structuring multicriteria resource allocation models (MRAMs) in the auditing context?**

To carry out its duties, CGU has a budget outlined in the Annual Budget Law (LOA), which defines the spending limits for the year. It is worth noting that these resources are scarce and the development of instruments to support the execution of these expenditures becomes pertinent and appropriate. CGU is facing a context with multiple objectives and programs, and a limited budget, addressing multiple expected benefits, characterizing a typical resource allocation situation.

In this sense, scientific knowledge of multicriteria decision analysis, particularly regarding resource allocation, can bring improvements to these internal work processes. Moreover, to properly structure an MRAM, it is necessary to get an understanding about the decision problem, for instance, identifying the stakeholders, identifying the goals and values, and identifying the alternatives and the constraints of the decision problem.

Thus, to answer the research question RQ1, the first objective of this thesis consists in proposing a framework to structure MRAMs in the context of auditing organizations. Specifically, the framework should define methods and techniques that can help to structure what is relevant to consider in MRAM modelling, so that the model has the potential to improve the internal processes of organizations that have budget constraints and perform audit and inspection actions, such as in the CGU.

- **RQ2 - How to design a socio-technical process to apply a MRAM structuring framework within an audit context?**

The second objective is to construct and apply a socio-technical process to implement the structuring framework in a real-world situation: methods, techniques and tools to structure a resource allocation model are to be defined and implemented in combination with participatory processes and used in a case study. Specifically, our case study is centred in the elaborating process of the SFC Operational Plan.

Proper participatory processes should be designed to involve multiple and cross-sectoral stakeholders, decision-makers and/or experts during the application of the framework. Involving key-actors at CGU creates more confidence and validity in the models outputs, promoting its usability for decision support, as well as promotes the acceptance and use of MRAMs (Phillips and Bana e Costa, 2007).

- **RQ3 - Under the presence of divergent and conflicting views between stakeholders, how to define a multicriteria-based negotiation process to support different groups of decision-makers in the selection of competing audit projects?**

In a context of resource allocation and portfolio analysis, once one is in situations under the presence of conflict or divergence of views between different decision-makers, one can seek to make use of negotiation techniques, integrated with multicriteria tools/instruments, to support negotiation and to search for a compromise solution.

The third objective of this thesis is to design and test a socio-technical methodology, based upon multicriteria resource allocation techniques, to support the selection of audit projects to be performed by CGU within a negotiation framework and taking into consideration the different views of those involved in the choice of audit projects and while promoting convergence towards agreement.

- **RQ4 - How to design a Decision Support System, making use of the data available in auditing information systems, to support auditing resource allocation negotiation and decision-making at CGU?**

The final objective of this study is to design a DSS module architecture for the CGU information system. It should contain the main features of the methodology developed by the previous studies and, thus, allowing improvements in the multicriteria evaluation and negotiation of audit projects. The

DSS should provide interactive and flexible mechanisms/instruments for stakeholders to analyse relevant data and making choices of the type of audit projects at hand, to analyse the generated portfolios and to support negotiation.

1.4. Structure of the PhD thesis

In this research study, the research methodology adopted follows the socio-technical school of thought, according to the constructivism paradigm in the context of decision support (Bana e Costa et al., 2004; Bana e Costa and Pirlot, 1997). This epistemology is selected as suitable to our decision-making context in light of the modern paradigm of learning and requisite modelling (and as opposed to the normative paradigm). Also, theoretical and methodological issues of design research were considered during the elaboration of the thesis (Collins et al., 2009).

The structure of this thesis was conceived in line with the objectives and underlying research questions above described, to develop a socio-technical multicriteria methods and tools to enhance multicriteria resource allocation with negotiation tools to assist decision-makers in the selection of audit projects.

Figure 2.1 depicts the general framework for this thesis, showing how the four studies relate between them.

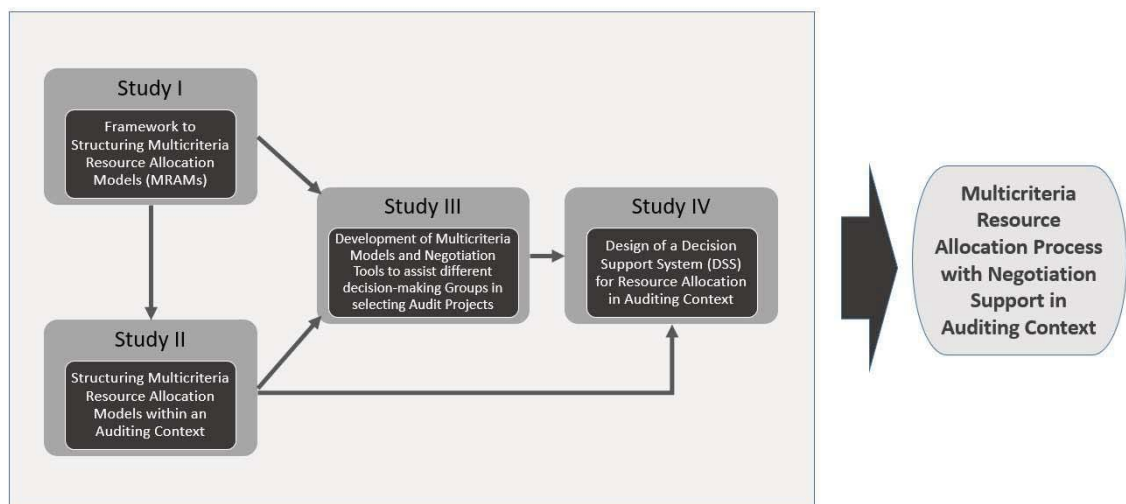


Figure 2.1 – General framework of the PhD thesis.

Therefore, this thesis is organized in six chapters and three appendixes, including an introduction chapter (Chapter 1), four research chapters related to each of the research questions outlined before (Chapters 2-5), and a final chapter presenting the final remarks, and discussing relevant issues and directions for future research (Chapter 6).

The first study of this work, entitled *“Structuring Multicriteria Resource Allocation Models: A Framework to Assist Auditing Organizations”*, corresponds to Chapter 2 in the thesis. This chapter provides a literature review of the methods and tools that can aid structuring models for resource allocation in auditing context. In addition, it proposes a framework with techniques and tools to support the structuring of multicriteria resource allocation models, so that these models have a potential to assist organizations in evaluating and selecting audit projects.

The second study of this thesis, entitled *“Structuring Multicriteria Resource Allocation Models within an Auditing Context”* is presented in Chapter 3. This chapter designs and applies a social-technical process – to implement the framework described in Chapter 2 – in which members of the CGU participated on the structuring of multicriteria resource allocation models, namely in the process of elaborating the SFC Operational Plan. This study included the application of a web questionnaire to an audience composed of Directors, Superintendents of Regional Offices, Audit Coordinators, Audit Team Heads and Technical Advisors.

Chapter 4, entitled *“Enhancing Multicriteria Resource Allocation with Negotiation tools to assist decision-makers in the Selection of Audit Projects”*, proposes a methodology to build MRAMs to assist the evaluation of the audit projects that compose the SFC portfolio and the selection of these projects, integrated with negotiation tools. The proposed MRAMs consider and are informed by the different views and interests of the stakeholders involved in the allocation processes of audit resources within the CGU and for that purpose, an informed negotiation framework supported by integrative negotiation techniques was developed.

The next chapter, entitled *“Enhancing Negotiation within Multicriteria Resource Allocation in Auditing: Designing a Decision Support System for CGU”*, corresponds to Chapter 5 of the PhD thesis. This chapter, based on existing corporate systems at CGU, presents a DSS negotiation module architecture proposal to enable the development of multicriteria resource allocation tools to assist decision-makers in selecting audit projects in a systematic way, in order to facilitate the interface between decision-makers and negotiation techniques to support the portfolio selection in the auditing context. This is intended to allow better use and systematization of data available in the audit projects' records already carried out by CGU teams.

Finally, Chapter 6 presents the final remarks arising from this thesis, by summarizing the findings of each chapter with reference to the respective research question and highlighting suggestions for future research.

The research work developed throughout this thesis was presented in some conferences and scientific meetings. As Chapters 2 to 4 were prepared in the format of a scientific paper, oriented to be published in scientific conferences or journals, some repetitions across these chapters may be found. This is particularly true regarding the context and description of the case study that follows in research Chapters 2 to 4. Short versions of Chapters 2 and 4 were presented at scientific conferences and published as conference proceedings, with these chapters being rewritten as extended versions of these papers. A slightly different version of Chapter 3 was presented as a full paper at another scientific conference. Moreover, one scientific article is being prepared, with the contribution related to the combination of multicriteria modelling with negotiation processes at CGU, for submission to a peer-reviewed international journal. These outputs are described below.

Articles published as conference proceedings

CP1. Vivas, V. and Oliveira, M. *Structuring Multicriteria Resource Allocation Models - A Framework to Assist Auditing Organizations*. In Proceedings of the 6th International Conference on Operations Research and Enterprise Systems (ICORES 2017), pages 321-328. ISBN: 978-989-758-218-9. DOI: 10.5220/0006189503210328

CP2. Vivas, V. and Oliveira, M. *Which Tools Are Needed to Assist Audit Managers in Project Portfolio Selection When Divergent Views Emerge?* In Proceedings of the 8th International Conference on Operations Research and Enterprise Systems (ICORES 2019), pages 338-345. ISBN: 978-989-758-352-0. DOI: 10.5220/0007374003380345

Oral presentations in conferences

OP1. Vivas, V. and Oliveira, M. *Structuring multicriteria resource allocation models within an auditing context*. XVI Congresso Internacional de Contabilidade e Auditoria – XVI CICA, Aveiro, October 2017.

Articles under preparation for publication in peer-reviewed journals

J1. Vivas, V. and Oliveira, M. *Enhancing Multicriteria Resource Allocation with Negotiation Tools to Assist Decision-Makers in the Selection of Audit projects* (paper to be submitted to an international journal).

Chapter 2 STRUCTURING MULTICRITERIA RESOURCE ALLOCATION MODELS: A FRAMEWORK TO ASSIST AUDITING ORGANIZATIONS

Multicriteria resource allocation models (MRAMs) have been extensively employed in the literature to support decision-makers to achieve their objectives by supporting the definition of portfolio of activities to be executed subject to resource constraints. These models are particularly important in public organizations, which involve decision-makers faced with alternative courses of options/projects/programmes that, if selected, consume resources and lead to consequences with regard multiple criteria. Despite the potential of these models to promote an effective use of scarce resources, there is little organized and integrated research on how to structure them. These models have a potential to assist auditing organizations in evaluating and selecting audit projects. In this chapter, we propose a framework with techniques and tools to support the structuring of MRAMs to assist auditing organizations. The framework entails a set of methods, techniques and tools available in the literature to support the structuring of MRAMs and we provide illustrative examples on to apply these techniques and tools in the context of the Comptroller General of the Union (CGU), the Ministry of the Brazilian federal government responsible for helping the Brazilian government regarding the treasury, federal public assets application and the government's transparency policies.

2.1. Introduction

Similar to public auditing organizations in other countries, the activities of CGU integrate actions of corruption prevention, fraud deterrence, public accounting, comptroller, ombudsman activities and increased transparency in management. CGU has a key role in promoting transparency and accountability in public spending. Since resources are scarce, CGU public managers must choose the set of projects to be executed with the available budget, considering costs and expected returns. This is a resource allocation situation well recognized in literature and, in this context, the use of multicriteria decision analysis (MCDA) concepts and tools can become useful and necessary (Archer and Ghasemzadeh, 1999; Kleinmuntz, 2007; Lourenço et al., 2008).

MRAMs have been reported in the literature to support decision-makers in selecting options/projects/programmes, taking into account of costs, benefits and risks (Liesiö et al., 2007; Phillips and Bana e Costa, 2007; Lourenço et al., 2012; Oliveira et al., 2012). These models are particularly important in public contexts in which resources are limited and there is an increasing demand for transparency and accountability in spending. Despite the potential of these models to promote an effective use of scarce resources, there is little organized and integrated research on how to structure them (Montibeller et al., 2009). Proper structuring is required for building models that can effectively assist decision-makers.

This study aims to fill this gap by proposing a framework to structure MRAMs in the context of auditing organizations. Specifically, the framework defines procedures and methods that can help to structure MRAM with a potential to improve the internal processes of organizations that have budget constraints and perform audit and inspection actions, such as in the CGU. The remainder of the chapter is structured as follows. The next section outlines broadly the multicriteria resource allocation problem and key approaches set out in the literature to address those problems. Then we suggest a set of techniques and tools for the structuring MRAM and provide examples of its application for the auditing context. The chapter ends with discussion of some relevant issues and directions for future research.

2.2. The (Classical) Resource Allocation Problem

2.2.1. General Definition

A multicriteria resource allocation problem is characterized by the selection of attractive projects (portfolio) to be financed under the presence of a limited budget and of other relevant constraints. So, the prioritization and/or selection of options aims at generating portfolios of projects – which entail multiple benefits, costs and uncertainties – that offer the best overall value for a given budget. Clearly, the analyses of portfolios will depend on how the organization's decision-makers values distinct project benefits and risks, as well as on the costs required by those projects and by context constraints. As these benefits are usually multi-dimensional (e.g., losses recovery, strategic fit, social responsibility, safety etc.), this is a multicriteria problem.

The multicriteria resource allocation literature suggests two main modelling approaches that can inform the prioritization and/or the selection of projects and that can be used by the CGU: the optimization approach (Bana e Costa and Soares, 2004; Liesiö et al., 2007; Lourenço et al., 2012;

Oliveira et al., 2012) and the prioritization approach (Bana e Costa et al., 2006; Phillips and Bana e Costa, 2007), which we now briefly describe.

2.2.2. The Optimization Approach

Following Oliveira et al. (2012), the performance x_{ij} of each project j in the benefit criterion i can be measured by a level in the respective descriptor, with partial value $v_i(x_{ij})$. A descriptor of impact can be considered as an ordered set of impact levels on each of the criteria, which intended to operationalise the appraisal of impacts, in terms of performance or consequences, describing the impacts of options with respect of criteria in order to better frame the evaluation model (Bana e Costa and Beinart, 2005). Under an additive structure (which requires the respect for mutual independence conditions), the value of the overall benefit v_j of the project j , with k_i represent the weight assigned to criterion i , can be determined as Equation (2.1):

$$v_j(x_{1j}, \dots, x_{nj}) = \sum_{i=1}^n k_i \cdot v_i(x_{ij})$$

$$\sum_{i=1}^n k_i = 1 \text{ and } k_i > 0 \text{ (} i = 1, \dots, n \text{)}$$
(2.1)

Considering each project j has $v_j > 0$ and cost c_j , B is the total of available resources, and as $l_j = 1$, if the project j is included in the best portfolio and *zero* otherwise, we have:

$$\text{maximize: } \sum_{j=1}^m v_j l_j$$
(2.2)

$$\text{subject to: } \sum_{j=1}^m c_j l_j \leq B,$$
(2.3)

$$l_j \in \{0,1\}, \quad j = 1, \dots, m.$$

The best project portfolio will be found by solving this optimization problem (Equations 2.2 , 2.3). Additional constraints can be considered.

2.2.3. The Prioritization Approach

Following Bana e Costa et al. (2006), the prioritization approach can be applied in six steps, in which the first three steps are similar to the optimization approach but also necessary:

1. List the projects;
2. Use a multicriteria value model, as Equation (2.1), for instance, to determine the added expected benefit v_j , if the project j is financed;
3. Define the cost c_j of each project, equal to the amount of financial support funding;
4. Calculate the benefit-to-cost ratio ($r_j = v_j/c_j$) of each project;
5. Rank the projects from the highest to the lowest benefit-to-cost ratio; and,
6. Go down the list, choosing projects until the available budget is depleted.

A variant of this prioritization approach is found in Phillips and Bana e Costa (2007), that use the Equity, a software for portfolio analysis, which enables a classification of projects within an organizational structure logic. Specifically, the funds can be spent on different levels in various organizational units or functions, called areas. In each of the areas K , the options are evaluated based on criteria of benefits and risks J , resulting in $K \times J$ scales. For a given criteria j is assigned a within criteria weight w_{jk} . The total value of each option i and the benefit-cost ratios are (Equation 2.4):

$$V_i = c \frac{\sum_j w_j \cdot w_{jk(i)} \cdot v_{ij}}{\sum_j \sum_k w_j \cdot w_{jk}} \quad (2.4)$$

$$r_i = \frac{V_i}{C_i} \quad (2.5)$$

The options are ranked from highest to lowest ratio r_i (Equation 2.5). The Equity structure can also be used within an optimization approach, although requiring a more sophisticated optimization model.

Several decision support tools assist the implementation of both approaches, being that the case of PROBE - Portfolio Robustness Evaluation (Lourenço et al., 2012), RPM - Robust Portfolio Modelling (Liesiö et al., 2008, 2007; Vilkkumaa et al., 2014a) and the resource allocation module of M-MACBETH (Bana e Costa et al., 2012; Hummel et al., 2017), which we outline in the next section.

2.3. Decision support tools

As previously stated, some decision support tools can support the implementation of both the prioritization and the optimization approaches. We can mention PROBE (Portfolio Robustness Evaluation), a multicriteria Decision Support System (DSS) for portfolio robustness evaluation. PROBE identifies all efficient portfolios, either convex or non-convex efficient, depicting the respective Pareto frontier, within a given portfolio cost range, and allows performing in-depth interactive analysis of the robustness of selecting a proposed portfolio. The system implements the optimization approach but also finds the solutions given by the prioritization approach (Lourenço et al., 2012). In turn, RPM (Robust Portfolio Modelling) is a methodology that extends Preference Programming methods into portfolio problems where a subset of project proposals are funded in view of multiple evaluation criteria. In Preference Programming, incomplete information are accommodate by means of set inclusion (i.e., the 'true' parameter is contained in a feasible set described by the decision-maker's preference statements). In RPM, the values of individual projects as well as project portfolios are modelled by an additive weighting model and incomplete information about criterion weights is captured through linear inequalities, while intervals are employed to model the performance of projects with regard to different criteria (Liesiö et al., 2007).

Damart et al. (2007) brought an approach to address the situation of multicriteria sorting problems, where a group aim together develop a common multicriteria evaluation model to sort actions. The authors point out *"a multicriteria sorting model requires defining values for its preference-related parameters. However, the decision maker (DM) often finds it is difficult to express his/her preferences as precise numerical values, correctly taking into account the role played by each parameter"* (Damart et al., 2007, p.1464). The study was based on an approach for the ELECTRE TRI method and implemented on the DSS IRIS.

We can also highlight MACBETH (the Measuring Attractiveness by a Categorical Based Evaluation TechNique), an interactive multicriteria decision support approach that allows evaluating the options on various criteria using qualitative judgments of attractiveness differences in order to generate value scores for the options in each criterion and weights for the criteria. It is supported by the M-MACBETH DSS and has a newly developed resource allocation module that, based on sound methodology MACBETH, supports all phases of the decision-making process, addresses the baseline problem, brings optimization and benefit/cost prioritization, and may also considers others constraints (Bana e Costa et al., 2012; Sanchez-Lopez et al., 2012).

Additionally, Lourenço et al.(2008) present a study of four commercial software (Equity, HiPriority, Logical Decisions Portfolio (LDP) and Expert Choice Resource Aligner (ECRA) for multicriteria portfolio analysis based on the additive aggregation of multiple benefit criteria. As highlighted by the authors, *“the key technical distinction between the software packages analysed concerns the type of resource allocation procedure used: Equity uses the benefit-to-cost ratio approach; HiPriority use the benefit-to-cost ratio approach and also uses an exhaustive enumeration approach; whereas LDP and ECRA use the mathematical programming approach. Therefore only LDP and ECRA can deal with additional constraints.”*

2.4. Auditing Context

Both the prioritization and optimization modelling approaches can be useful for assisting decision-making processes of auditing organizations, as directly or indirectly shown by distinct studies: Bradbury and Rouse (2002) point out that the audit risk assessment is an essential part of the audit planning process. As the authors explain, numerical risk scores for each audit unit, together with materiality, can be used as the basis for the audit resource allocation. In turn, some studies have presented models to allocate internal auditing time and others auditing resources to projects (Krüger and Hattingh, 2006; Mohamed, 2015), using the optimization approach. Studies focused on scheduling of audit works can also be found in the literature (Chang, 2002; Rossi et al., 2010).

Prior to the use of these models, one needs to structure the MRAM. I.e., to build such a model it is necessary to get all the information pertaining on models, which means defining the organizational areas, audit units, project options, costs, measurement criteria of benefits, risks, synergies and interdependencies between projects and other necessary factors (Friend and Hickling, 2005; Keeney, 1992; Montibeller et al., 2009), as well as to understand who should participate in model construction and whom the model is expected to assist. Such structuring will show whether an optimization or a prioritization approaches should be used, and whether these approaches need further development.

2.5. Pre-considerations for Structuring MRAM

The framework presented in this chapter addresses those managers who work in the audit environment and seek instruments to support their decisions in the most structured and transparent possible way. Where to spend the resources available? How to plan the audit projects? Thereby, a number of preconditions needs to be defined, so that the techniques and tools of the framework

become useful to be applied in practice. To introduce these points, we look into the literature and outline a series of working assumptions for an effective use of the framework, in the sense of maintain a condition of order preservation to permit the construction of additive models (Bana e Costa and Beinat, 2005).

We can start by pointing out that the structuring process of a MRAM must begin with the definition and clarification of the decision problem with the decision-makers. This is a task that may seem simple but often the decision-maker does not have a complete idea of the problem being addressed. At this point, the use of visual framing tools can help to capture different aspects of the problem to be tackled, to seek the different perceptions of the actors involved and, in addition, to avoiding the type III error, that implies that the wrong question was asked and hence the wrong problem was solved (Clemen, 1996; Franco and Montibeller, 2011). From the above, we can then present the first working assumption:

Working Assumption 1 - Before structuring the resource allocation model, one must identify the type of decision problem to be addressed. It is appropriate to use visual tools to clarify the situation and avoid Type III Error.

Attention to stakeholders is needed to assess and enhance political feasibility of decision implementation (Franco and Montibeller, 2011). The existence of a plurality of points of view allows imagining different possible approaches to the problem, different intervention methods, and different decisional procedures (Ferretti, 2016). So, the framework should be flexible enough to be applied in the context of audit organizations where there are resource constraints, taking into account multiple and conflicting objectives, different types of constraints and different types of stakeholders.

There are several tools and techniques available in the scientific literature that can support the structuring of resource allocation models. There is no consensus on which ones are most effective. The choice of which tools to use depends on the context of the problem being addressed, on which tools best fit the culture of the organization, and on the user's familiarity with those tools. In the context of the audit, the project classes (corresponding to the audit projects) that will be evaluated by the resource allocation model can vary substantially. Thus, the structuring framework must support this flexibility, following a structured process that can be applied to different contexts, presenting the variants of the techniques and models for each situation with just important information. These considerations lead us to the second assumption:

Working Assumption 2 - Each stage of the framework must generate relevant information to the model building in a structured way, delimiting to generate the key information for the models, thus avoiding the users' exposure to unnecessary information. It is important that the process should be simple enough to generate trust and transparency in the results presented.

Projects should be evaluated according to attributes that reflect the organization values. Thus, one should seek, in a logical sequence, first eliciting the organization's goals, followed by the definition of the attributes to measure the achievement of these goals. The alternative (project) identified must be evaluated by these attributes, generating common measurements that can be calculated separately for each project. From this, we will have an unbiased comparison of the projects under consideration. Thus, we can emphasize the next assumption:

Working Assumption 3 - The resource allocation model should present evaluation measures that allow equitable comparison, unbiased, of the projects under consideration, and that reflect the organization's goals.

Besides that, in the context of the audit, one can have the situation with the presence of interdependences between some projects (synergies, precedence, complementarity, incompatibility, etc.). All of these factors can influence portfolio definition. Thus, project interactions implications for resource allocation models through direct dependencies or resource competition should be considered in resource allocation structuring process, which directs us to assumption 4:

Working Assumption 4 - The structuring of resource allocation model should consider the interdependencies between projects and its consequences (benefits) for the generated portfolio under the costs involved.

As the framework application depends on participatory methods that involve the participation of all stakeholders, creating reliability and engagement to move forward (Phillips and Bana e Costa, 2007), we can highlight:

Working Assumption 5 - Applying the framework will require the use of technical tools and concepts, as well to involve decision-makers into participatory processes, i.e., the adoption of a socio-technical process.

Since the framework is not based on a predefined model, the result to be presented will be determined by the whole process and different models may emerge, which can be translated into the sixth assumption:

Working Assumption 6 - The framework should be able to generate different models according to the suitability to the situation faced.

So, in the audit context, this integrated approach should support decision-makers in obtaining the portfolio of audit projects to be performed, according to the criteria of interest, in addition to taking into account different types of resource limitations and project interdependencies. The use of a systematic process may also contribute to increasing transparency and supporting equitable treatment of project proposals.

2.6. Structuring Resource Allocation Decision Models

Since the listed working assumptions support the delimitation of the situation to be addressed, as well as the main points that must be taken into account by those who need to structure a resource allocation model, we herein propose a framework with techniques and tools to help defining and structuring MRAM to assist auditing organizations. Departing from the work presented by Belton and Stewart (2002), the proposed framework, shown in Figure 2.1, is able to generate background information to build MRAM. Note that applying the propose framework will require the use of technical tools and concepts, as well to involve decision-makers into participatory processes (for instance, to build a multicriteria value model), i.e., the adoption of a socio-technical process (Phillips and Bana e Costa, 2007). In this chapter, we focus on the techniques, rather than on the social process.

Each stage of the framework must generate relevant information to building the model in a structured way. The choice of which tools to use depends on the context of the problem being addressed, on which tools best fit the organizational culture, and on the user's familiarity with those tools.



Figure 2.1 – Framework to assist the structuring resource allocation models.

Giving a problem example on auditing context to support the explanation of the framework stages, CGU performing an inspection program in states and municipalities, in order to assess the expenses incurred by these entities involving federal funds. The scope and entities to be inspected are chosen based on indicators divided into four dimensions: Control, Transparency, Economic and Social Development and Materiality. The main objective of an inspection cycle is to define the control actions (audit projects) that will be performed, within the available resources, which means defining auditing scope, auditees and measure expected returns/impacts.

2.6.1. Problem Identification

The first step is to identify the type of decision problem and understand the different relevant perceptions of the actors for the decision. Auditing organizations commonly need to choose the audit projects to be performed by audit teams, taking into account the audit risks and available resources. Is this a prioritization problem? Is this about project selection with budget constraints? Or, moreover, does project selection involve possible conflicts of interest? The identification of the decision problem type is a key factor for MRAM.

In this step we suggest the use of structuring tools for problem definition. Franco and Montibeller (2011) cited some useful tools for this step: cognitive mapping, dialog mapping, soft systems methodology (SSM), group model building.

As explained by Eden (2004), a cognitive map is a graphical representation of thoughts in a network shape containing nodes and arrows whose direction implies causality. It is a powerful tool to capture different aspects of the problem to be addressed and is helpful to clarify people's ideas and

perceptions. It is usually built in a hierarchical structure, which is usually in the form of a means/ends graph with goal type statements at the top of the hierarchy. Heads will usually represent goal type statements, meaning desired or undesired outcomes, and tails will be options.

Another tool is Dialog Mapping that seeks to build common understanding for wicked problems, which are ill structured and complex and can lead to different views and solutions depending on different stakeholders' perceptions. A diagram or map is shown in a shared display with use of a conversational grammar called IBIS, Issue Based Information System, that represents the moves in a conversation as questions, ideas (possible answers to the question), and arguments (pros and cons to the ideas) (Conklin, 2005).

Soft systems methodology (SSM) is an approach for dealing with problematical messy situations. Its use is recommended when divergent views on the problem definition exist. It is an action-oriented process of investigation in which users learn their way from finding out about the situation and what can be done to improve it (Checkland and Poulter, 2010).

In turn, a Group Model Building is a data analysis method from a group of decision-makers. The dynamic patterns and relationships between key factors discussed by the group are portrayed to talk and analyse, resulting in new insights and possible new strategies or scenarios (Richardson and Andersen, 1995).

In addition, Friend and Hickling (2005) have presented the Strategic Choice Approach (SCA) that is useful to support the creation and definition of the problem in uncertain contexts.

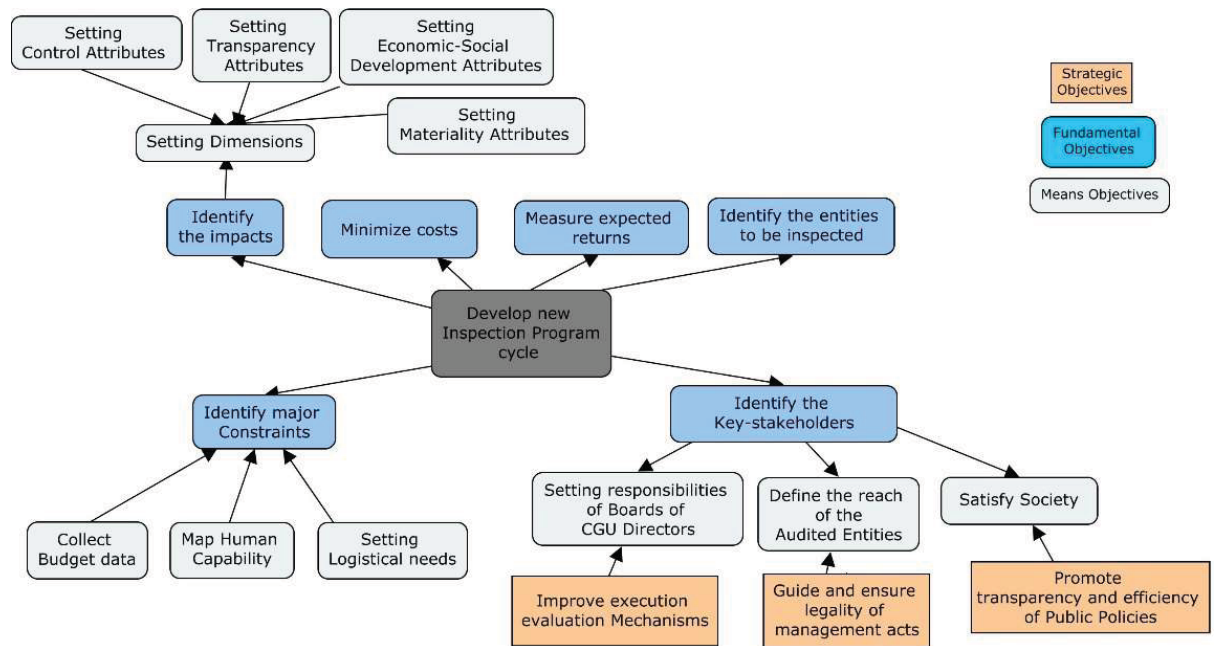


Figure 2.2 – Mapping key concerns for developing an inspection program cycle with a means-ends objectives network. An illustrative example within the context of the CGU.

Following Keeney's (1992) guidelines, one can also frame a decision situation by structuring the strategic, fundamental and means objectives through means-ends relationships.

Figure 2.2 illustrates the means-ends network for the CGU problem example described above. The map highlights key issues of the decision problem, namely the value system organized in a means-ends network. In fact, visual tools are useful to define and clarify the problem may be relevant in this step. In a development of a new inspection program cycle, we must to identify the impacts, the key stakeholders and their aims, the constraints as also measure the expected returns using the least resources possible. All of this must be done through a series of means-objectives, aligned with the strategic objectives of the CGU, namely: improve evaluation mechanisms; guide and ensure legality of management acts of audited entities; and, promote transparency and efficiency of Public Policies.

Once the problem is defined, as Franco and Montibeller (2011) well emphasized, it is necessary identify which aspects or particular decisional element of the decision problem will be evaluated in the model to be built. However, before that, we need to identify the key actors involved in the process.

2.6.2. Stakeholders' Identification

The next step seeks to identify the key stakeholders and analyse their power and influence on the decision context. Bryson (2004) presents an array of techniques useful for stakeholders' identification and analysis and which grouped into four categories, which should be used in this step: organizing participation; creating ideas for strategic interventions; building a winning coalition around proposal development, review and adoption; and implementing, monitoring and evaluating strategic interventions. The author highlights five stakeholder identification and analysis techniques to helping organize participation: a process for choosing stakeholder analysis participants; the basic stakeholder analysis technique; power versus interest grids; stakeholder influence diagrams; and the participation planning matrix. He lists six additional techniques to creating ideas for strategic interventions: bases of power and directions of interest diagrams; finding the common good and the structure of a winning argument; tapping individual stakeholder interests to pursue the common good; stakeholder-issue interrelationship diagrams; problem-frame stakeholder maps; and ethical analysis grids. The author also considers three techniques for proposal development review and adoption: stakeholder support versus opposition grids, stakeholder role plays and policy attractiveness versus stakeholder capability grids. And, finally, presents policy implementation strategy development grid for the last category.

From these techniques, we can highlight grouping the stakeholders in the matrix power/interest, proposed by Mendelow (1981), in which is possible to perceive how communication and relationships between stakeholders can affect the model structure and its implementation.

Figure 2.3 helps to understand differences in power and influence of key stakeholders in the CGU inspection program example. For instance, Public Policy agents that are responsible for the creation of Public Policies. In general, they have high power of influence on where the public resource will be invested however they are not directly interest on the CGU actions in inspection program. In turn, the auditees would be directly affected by these audit projects, which make them stakeholders with a low level of power but with a high level of interest.

		Level of Interest	
		Low	High
Power	Low	- General Public	- CGU Analysts - Auditees
	High	- Policy agents	- Minister - CGU-Regional Heads - Directors

Figure 2.3 – Power-interest matrix applied to an inspection action.

Ferretti (2016) pointed out that the identification of the fundamental objectives related to a decision is not an easy task without support people and showed that, under the existence of a plurality point of views, a participative decision process is decisive to include different perspectives and to facilitate the discussion. Thus, one needs to understand these differences, which requires the framework steps that follow.

2.6.3. Goals and Values' Identification

Once the problem and the stakeholders are identified, one needs to have an understanding of the goals and values of the stakeholder(s). We can underline the concept of decision framing presented by Keeney (1992) which points out that values are used for evaluation and should reflect the decision-makers objectives. He highlights that there are two distinct types of objectives, the fundamental objectives and the means objectives. While the former features an essential reason for the interest in the decision situation, the means objectives are just a way to achieve them. As the author also emphasizes, structure objectives give the basis for any use of quantitative modelling and the fundamental objectives hierarchy can indicate the set of objectives over which attributes should be defined.

In an audit environment, such as in CGU, there are a number of fundamental objectives, ranging from promoting the improvement and transparency of public management, preventing and combating corruption with social participation, as well as promoting the evaluation and control of public policies and of expenditure quality. These objectives need to be detailed to other levels according to the focus of audit project.

A structuring tool widely used in decision analysis is the value tree, which displays the family of key-concerns in a tree form and offers a useful visual overview of the main objectives in different levels of increasing specification (Bana e Costa, 2001; Bana e Costa et al., 2004; Bana e Costa and Beinat, 2005).

In Figure 2.4 we present a value tree with the fundamental objectives to be attained with an inspection action. For instance, the “Management Continual Improvement” objective is concerned with the assessment of the inspection program's objective component in terms of efficiency and technical quality as well as the agreement on the entities and the areas to be audited.

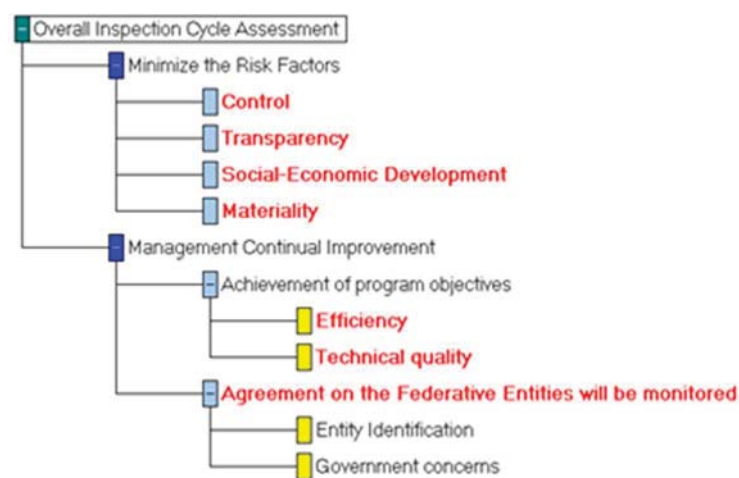


Figure 2.4 –Value tree for an inspection action (built with M-MACBETH).

At this stage, it is also important to look for the alternative's costs and identify the measurement criteria of alternative performances (expected benefits). One can make use of the framework for structuring options and areas and criteria presented in Montibeller et al. (2009). The authors propose two approaches to structuring criteria, based on Keeney's concepts: Alternative-focused thinking (AFT), which criteria are defined from the characteristics that distinguish options and Value-focused thinking (VFT), where the evaluation criteria should reflect the organization's values and strategic objectives.

A rich information source of benefits and costs that can be incorporated into the models can be obtained from existing corporate systems or current auditing databases.

2.6.4. Alternatives' Identification

The identification of decision alternatives, which in auditing context means the identification of audit projects that will be evaluated, is an important step in the structuring process and can be performed through different techniques / tools.

In organizations segregated by pre-defined areas, where the initial set of project options is relatively stable, it can be used the AFT above described, in which, after problem definition, the projects are identified and, then, the values (criteria) to consider in the evaluation are specified. In turn, on the VFT, organizational values and goals are initially set. The options are then created thinking on how to achieve these goals (Keeney, 1992).

One can still make use of cognitive map to explore/identify decision alternatives (Eden, 2004). Another useful tool presented by Howard (1988) is the strategy-generation table. It shows how a total strategy can be specified by combination of options under several dimensions, called strategy themes.

In the CGU inspection case, since the projects to be evaluated depend on the definition of the federal state to be inspected and the audit scope, we can map the set of options surrounding the inspection program to gain a better understanding of the issues, their interrelations and perceived implications to the model to be built.

2.6.5. Uncertainties' Identification

An analysis of which uncertainties are key for the evaluation of options and for the allocation of resources is required. To exemplify, uncertainties may be related with the budget, with the measurement of options performance and with the importance/weight of objectives.

Vilkkumaa et al. (2014) make a Bayesian modelling of uncertainties, to be considered in the selection of project portfolios. There is still another classification in Strategic Choice Approach to identify the uncertainties relating to the working environment, related to the guiding values and related to the choices in related agendas (Friend and Hickling, 2005). Thus, different uncertainty types may require different analysed with the prioritization and/or optimization modelling approaches.

In the auditing context, as highlighted by Krüger and Hattingh (2006, p.62), we can mention that *“risk is seen as a measure of uncertainty and is linked to the possible loss in an audit area — uncertainty in achievement of business objectives. The possible loss in an audit area will depend on specific characteristics and these characteristics are termed audit risk factors. Examples of well known and frequently used risk factors include complexity of operations, financial implications, recent changes,*

time since last audit, etc.” – these issues should be discussed for each context and have naturally an impact on the MRAM to be developed.

In the CGU example, a relevant audit risk factor to be considered in the model may be related to the uncertainty in estimate the project (control actions) values to be included in the inspection program portfolio.

2.6.6. Constraints’ Identification

It is also necessary to identify constraints that may be relevant for the allocation of scarce resources to competing projects. For instance, there may be resources/budget restrictions, synergies between projects or interdependencies between projects.

At this stage, in a brainstorm session/focus group, one can use VFT to elicit the main constraints involved in the decision problem by equations (Keeney, 1992). Analysis of Interconnected Decision Areas (AIDA) can also help with Option Bars that bring the incompatibilities that can be translated into equations to be added to the value model used (Friend and Hickling, 2005).

In the CGU case, it is important to consider the following constraints:

Budgetary. Identify financial cost of each audit project and prioritize projects within the available budget, so as to be accounted for in Equation (2.3).

Logistical. The distribution of teams available for each audit project needs to be accounted for (e.g., equipment, vehicles, and special displacements). Whereas h_{kj} the amount of resources k consumed by the project j and H_k the total available resources k . It has been as in Equation 2.6:

$$\sum_{j=1}^n h_{kj} l_j \leq H_k \quad (2.6)$$

Context. Projects of entities identified as vulnerable should be positively discriminated. Be the corresponding v project to the federal entity identified as vulnerable, one should have (Equation 2.7):

$$l_v = 1 \quad (2.7)$$

2.6.7. Interactions between the Stages

To complete the structuring process, one cannot apply the framework without considering the joint analysis of different framework stages, as these are key to select and/or develop MRAM. Table 2.1 summarises techniques and tools included in the proposed framework. The diagonal includes techniques and tools previously described, and the remainder cells provide tools that can assist more complex analyses.

Despite the framework shown in a structured and sequential manner, the steps to be developed sometimes need to be analysed together. Some interactions between the framework steps can generate implications for the generated models. Depending on the situation complexity, models need to be adapted or new models must be developed.

Table 2.1 – Selection of techniques and tools that can assist structuring (crossing framework stages).

	Stakeholders	Goals and Values	Alternatives	Uncertainties	Constraints
Stakeholders	Stakeholder Power-interest Grid Stakeholder Visualization Influence Map	Negotiation Analysis Drama Theory	Conflict Dissolution Bargaining Drama Theory		
Goals and Values	Negotiation Analysis Drama Theory	Value Tree Decision framing Fundamental Objectives Hierarchy	Value Tree Causal Map and MCDA	DSS PROBE RPM	
Alternatives	Conflict Dissolution Bargaining Drama Theory	Value Tree Causal Map and Multicriteria Decision Analysis (MCDA)	Cognitive Map AFT, VFT Strategy Table		AIDA in SCA RPM
Uncertainties		DSS PROBE RPM		Bayesian modelling SCA Risk Factor Analysis	
Constraints			AIDA in SCA RPM		Brainstorm Focus group VFT AIDA in SCA

Analysing the influence of the stakeholders on the goals and values or on the alternatives' identification, it is noticed that different stakeholders (single, multiple, group) can lead to different goals and values and can generate different sets of alternatives and criteria. In this situation, it may be useful to apply conflicts dissolution modelling techniques to have an understanding for possible win-win solutions, which are often used for evaluation models but can be adapted to the structuring context. (Bana e Costa et al., 2001; Edwards et al., 2007) As implications for resource allocation models, we can cite:

- **Group of stakeholders:** The necessity for using techniques conflict dissolution in brainstorming session/focus group (Bana e Costa, 2001; Bana e Costa et al., 2001; Salo, 1995). With the adoption of a constructive (learning) value focused perspective, the authors framed each individual value and solutions into the value matrix. Once verified that there are no "win-win" solutions, they try to generate these solutions to satisfy everyone based on value structuring and clarification.
- **Multiple stakeholders:** Preparation of a cognitive map to every stakeholder, analysis of common and divergent characteristics. Conducting focus group/brainstorming sessions for the preparation of an aggregated map (Ferretti, 2016). The use of negotiation analysis/drama theory (Edwards et al., 2007; Rosenhead and Mingers, 2001) and even bargaining proceeds (Chatterjee and Samuelson, 1983; Ehrgott et al., 2012) can be useful.

As Sebenius (1992) emphasizes, Negotiation Analysis is a prescriptive theory conceptually located between decision analysis and game theory. *"It generally emphasizes assessment of the parties' underlying interests, alternatives to negotiated agreement, approaches to productively manage the inherent tension between competitive actions to "claim" value individually and cooperative ones to "create" value jointly, as well as efforts to change perceptions of the negotiation itself."*(Sebenius, 1992, p.18)

Also, Drama Theory proposes an overall model of conflict and its resolution that extend Game Theory. Search analyse how conflicts change and evolve over time, and not only rational choice within the fixed games. Encourages exploration of deliberate changes imposed on characters by the pressures of the dilemmas they face. (Rosenhead and Mingers, 2001)

On the other hand, when it comes to positional (or zero-sum, or fixed-pie) negotiations, usually bilateral, and the assessments of alternatives on the two sides are diametrically opposed, there is the necessity of bargaining proceeds (Ehrgott et al., 2012). Though abstracting from the dynamics of the

negotiation process, the bargaining procedure highlights the fundamental strategy trade-off faced by each player to find results that are preferred to the status quo for both parties.(Chatterjee and Samuelson, 1983)

In turn, the definition of the objectives and values of the organization have a direct influence on the definition of possible alternatives (projects) for the portfolio to be built. After all, the projects to be evaluated by the value model must be aligned with the organizational objectives. In this case, the use of value trees and causal maps can clarify and support the creative emergence of new alternatives. Montibeller and Belton (2006) proposed the causal map, which can also be used to identify and agree to a set of potential strategic options. As the authors highlight, a causal map is a network of inter-linked concepts (ideas) which tries to represent the discourse of a person through means-ends structure, whereby decision options are means of achieving the decision-makers' goals. Then, it can have the decision-makers' ends/goals at the top (nodes with only in- arrows) and decision options/means at the bottom (nodes with only out-arrows), as shown in *Figure 2.5*.

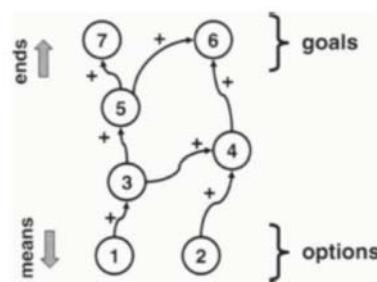


Figure 2.5 – Goals and options in a causal map (source: Montibeller and Belton, 2006).

Regarding uncertainties, it also may be related to the objectives and values, since the weights of the criteria might influence the evaluation of the project - in this case robustness analysis and impact measurement can be used and new equations may need to be added to the optimization / prioritization models. It can be supported by DSS PROBE and RPM methodology mentioned before. DSS PROBE allows the user to input plausible cost ranges, plausible benefit scores ranges or linear relationships on the weights and, then, calculate by optimization the feasible benefit value range for each project, which enable portfolio robustness evaluation within a user-defined uncertainty domain (Lourenço et al., 2012). In the RPM methodology, *“incomplete information is modelled by means of set inclusion. Thus, instead of using point estimates for weights and scores, the analysis is based on the*

consideration of sets of feasible parameters that are consistent with the DM's preference statements" (Liesiö et al., 2007, p. 1490).

A similar pattern can be observed regarding the constraints and their influence in the alternatives identification. A robustness analysis is also necessary. In turn, one may apply analysis of interconnected decision areas (AIDA) technique, present in Strategic Choice Approach (Friend and Hickling, 2005), that allows visualization of the compatibilities and incompatibilities of options within a problem focus, as shown in Figure 2.6 for the inspection action case.

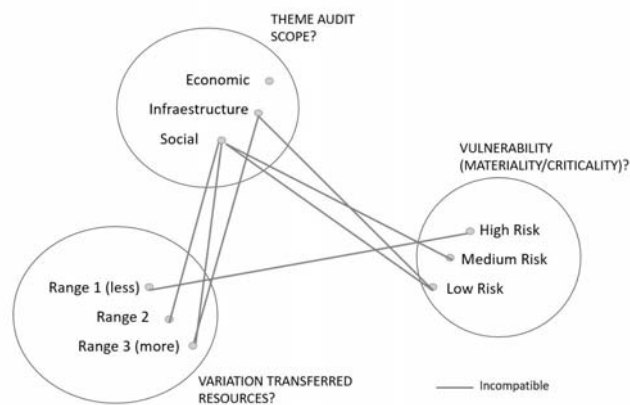


Figure 2.6 – An example of areas of interconnected options for an inspection action.

Thus, the result to be presented will be determined by the whole process and possibly different MRAMs may emerge. Therefore, the modelling approaches presented in Section 2.2 may need to be enhanced and developed for the context.

2.7. Discussion

This study combined decision making techniques and tools to support the structuring of MRAMs for the auditing context, in an attempt to aid stakeholders involved in the auditing decisions and which are pressured and charged for transparency and accountability in public spending.

Departing from a framework with the steps required to generate background information to build a MRAM and through an extensive review of the decision analysis literature, we have identified and consolidated, in an integrated and organized manner, several useful methods and techniques to support each stage to structuring these models. These stages included: problem identification,

stakeholder identification, goals and values identification, alternative identification, uncertainties identification, and constraint identification.

The application of the framework requires thinking about which decision-makers and stakeholders should be directly involved in each framework stage, together with a facilitator, an analyst, a recorder and/or others necessary roles in the process (Richardson and Andersen, 1995). This is necessary so that decision-makers will have confidence in MRAM results.

It was observed throughout the study that there are various techniques available in the literature to address each of these techniques but they were sprayed in the literature and have never been presented in an integrated form and structure as brought in this study. For the same reason, the list of tools presented is not exhaustive and there may be other techniques in the literature that were not mentioned in this study. Besides that, the choice of which techniques and methods that will be used will depend on the decision context of each situation to be faced, on which tools best fit the culture of the organization, and on the user's familiarity with those tools.

From all of the foregoing, this chapter has provided, in an integrated and structured manner, techniques and methods for building multi-criteria resource allocation models to support decision-makers within the audit context. To confirm and validate the applicability and usefulness of the developed framework, we must design a socio-technical process and test the techniques suggested. The next chapter brings us the methods designed to apply the framework and the results from its application in a real-world situation.

Chapter 3 STRUCTURING MULTICRITERIA RESOURCE ALLOCATION MODELS WITHIN AN AUDITING CONTEXT

At a time when public resources are particularly scarce and there is a need for transparency, it is recognised the role of audit actions in diagnosing the quality of public spending. In such context, there is a need for auditing organizations being accountable and allocating their resources efficiently. In this chapter, we propose and apply methods to apply the framework described in Chapter 2, defining which features multicriteria resource allocation models (MRAMs) should have at the Comptroller General of the Union (CGU), in Brazil, so they have the potential to assist organizations in evaluating and selecting audit projects. The proposed methods integrate a social-technical process in which members of the CGU participated in the model structuring and a wide range of rich information was generated.

3.1. Introduction

An audit project or a control action primary purpose is to promote the improvement and transparency of management through the assessment of spending quality and through the control of the audited entity's operations. One of the major challenges faced by public and private organizations that perform audits is how to plan the allocation of resources to its activities. Since resources are scarce and the requests for audit work are high, an objective recognised within those organizations is to allocate resources efficiently in a structured and transparent way. Thus, it is necessary to define which audit projects will be executed within the available resources and that will bring the greatest expected benefit, a classic situation tackled by portfolio management.

Several multicriteria models for resource allocation have been reported in literature to support decision-makers in managing portfolios, taking into account of costs, benefits and risks (Liesiö et al., 2007; Phillips and Bana e Costa, 2007; Lourenço et al., 2012; Oliveira et al., 2012). However, there is little indication in the decision sciences and operational research literature on how to structure such type of problems in an integrated and organized manner (Montibeller et al., 2009), with proper structuring being required for building models that can effectively assist decision-makers. Furthermore, up to our knowledge MRAMs have not been reported for the auditing context by literature in the area.

Within this context, a framework to support structuring MRAMs in an audit context was developed in the previous chapter (and reported in (Vivas and Oliveira, 2017)). The framework generally combines decision making techniques and tools to support the structuring of MRAM that can be used in practice, in an attempt to aid stakeholders involved in auditing decisions and which are pressured and charged for transparency and accountability in public spending. This chapter presents the methods designed to apply the framework and the results from its application in a real-world situation.

The context selected to apply the aforementioned framework was the CGU in Brazil. Specifically, our case study is centred in the process of elaborating the Operational Plan in the Comptroller Department of CGU (*Secretaria Federal de Controle Interno – SFC* in Portuguese). The SFC Operational Plan contains the audit projects to be performed by the audit teams during the year. Given the large number of audit projects that should be executed by the SFC and the need to efficiently allocate available auditing resources, it is necessary to prioritize these audit projects in order to guide the formulation of the SFC Operational Plan. Current procedures adopted by SFC do not compare the benefits, costs and risks of audit projects on a common and transparent basis.

Accordingly, this study reports applied work – departing from the generic framework proposed by (Vivas and Oliveira, 2017) and reported in Chapter 2 – to understand what is important to consider in a model to allocate auditing resources in the SFC context. The implementation of the framework required the definition of a socio-technical process, in which methods, techniques and tools to structure a model are defined in combination with participatory processes involving members from SFC.

The remainder of this chapter is structured as follows. We first present the current process followed in the elaboration of the SFC Operational Plan and explains the relevance of developing MRAMs to assist decision-makers in that context. Then, we briefly introduce the framework to support the structuring of a MRAM. In the next section we describe the socio-technical process that we have built to implement the framework, then present the results from its application. The chapter concludes by indicating which features need to be considered by MRAMs at the CGU context and by reflecting upon the added value of the framework.

3.2. Case Study

3.2.1. The Current Process of SFC Operational Plan Elaboration

Given the limited operational capacity, the large universe of auditable objects and the need to maximize results to be presented by the SFC, an instrument is essential to assist the process of selecting audit projects within the SFC Operational Plan, which currently works as follows.

The proposals for audit projects that will compose the SFC Operational Plan are presented in three negotiation rounds. In the first, mandatory audit projects are proposed, which contain the audit projects established in legislation, regulations or agreements, with a fixed term. In the second round, audit projects are proposed regarding priority themes defined by the board of directors. In the third round, audit projects are planned on the other auditable topics that have not been listed as priorities. The SFC managers involved in this process are the heads of the Audit Units, which can be either Audit Coordinations or CGU Regional Offices. They are responsible to make proposals for all audit projects that can compose the Operational Plan and are of interest to the Audit Unit, according to the criteria of materiality, relevance and criticality. The choice of which projects will be part of the portfolio depends on the available resources, and should consider cost and expected returns. The final decision about the projects that will compose the Operational Plan must be submitted to the approval of the SFC board of directors. Thus, the SFC Operational Plan materializes the audit projects to be performed during the year and should contribute to the achievement of the mission, vision and strategic objectives in the following axes: results, internal processes, people and infrastructure.

Notwithstanding the strategic nature of decisions on which audit projects to select, there is a lack in the SFC management of a procedure to evaluate the benefits, risks and costs of audit projects in a transparent and systematic basis. This is despite the fact that such decisions aim at pursuing multiple objectives – normative compliance verification, management evaluation, public policies analysis, etc. – and need to consider the views of several individuals working at the SFC, as well as need to consider the limited resources and capacity to implement all requested audit projects. This context fits a classical multicriteria resource allocation situation which is characterized by the selection of attractive audit projects (i.e. projects that constitute a portfolio in the project management literature) to be agreed under the presence of a limited budget and of other relevant constraints. So, the prioritization and/or selection of options aims at generating portfolios of audit projects – which entail multiple benefits, costs and uncertainties – that offer the best overall value for a given budget.

Nevertheless, the analyses of portfolios need to consider the views of auditing stakeholders working at SFC and, therefore, the use of MRAM to support decisions in this context can be useful and necessary.

3.2.2. Is the framework applicable to the Case Study?

A number of preconditions needs to be observed so that the steps of the framework defined in (Vivas and Oliveira, 2017) become useful and can be applied in practice. In this section we analyse whether each of the working assumptions required to apply the framework are observed in the SFC context:

Working Assumption 1 - *Before structuring the resource allocation model, one must identify the type of decision problem to be addressed. It is appropriate to use visual tools to clarify the situation and avoid Type III Error.*

After some preliminary conversations with members from SFC board of directors, they recognise the need to improve the current process used by the SFC to elaborate the Operational Plan, in line with enhancing trust and transparency, as well as the usefulness of using tools to inform the evaluation of audit projects on a common basis and the allocation of resources.

Working Assumption 2 - *Each stage of the framework must generate relevant information to the model building in a structured way, delimiting to generate the key information for the models, thus avoiding the users' exposure to unnecessary information. It is important that the process should be simple enough to generate trust and transparency in the results presented.*

The SFC Operational Plan elaboration process should must follow a structured process, in a logical sequence, which should be understandable to all involved and aimed at compromise with the results achieved. Thus, also assumption 2 is respected and we can emphasize the next assumption:

Working Assumption 3 - *The resource allocation model should present evaluation measures that allow equitable comparison, unbiased, of the projects under consideration, and that reflect the organization's goals.*

The SFC Operational Plan must take into account the priorities defined by the board of directors and establish criteria to measure audit projects according to the strategic objectives. The objectives of the audit projects execution are related to the production of relevant results that modify the auditee

reality and bring improvements to the public policy management. This should be reflected in the project measurement criteria.

Working Assumption 4 - The structuring of resource allocation model should consider the interdependencies between projects and its consequences (benefits) for the generated portfolio under the costs involved.

Besides that, in the audit context, one can have the situation with the presence of interdependences between some audit project (synergies, precedence, complementarity, incompatibility, etc.). All of these factors can influence portfolio definition. In the Operational Plan elaboration process, it is necessary to take into account the situations of transversality and interdependence between the audit projects to be executed, which may be related to the topics or SFC lines of action (Annual Audit of Accounts, Government Programs Execution, External Resources Audit, etc.). Thus, audit projects interactions implications for resource allocation models through direct dependencies or resource competition should be considered in resource allocation structuring process, which directs us to respect the assumption 4.

Working Assumption 5 - Applying the framework will require the use of technical tools and concepts, as well to involve decision-makers into participatory processes, i.e., the adoption of a socio-technical process.

As the framework application depends on participatory methods that involve the participation of all stakeholders, creating reliability and engagement to move forward (Phillips and Bana e Costa, 2007), we discussed this issue with members of SFC that agreed on the importance of involving its members in the development of tools to inform decision-making of audit projects .

Working Assumption 6 - The framework should be able to generate different models according to the suitability to the situation faced.

Since the framework is not based on a predefined model, the result to be presented will be determined by the whole process and different models may emerge. As the SFC Operational Plan is an instrument of annual periodicity, the elaboration process must be easily adapted to different contexts and allow periodic adjustments, so which we have alignment with the sixth assumption.

The listed assumptions support the delimitation of the situation to be addressed, as well as the main points that must be taken into account by those who need to structure a resource allocation

model. As all the preconditions to apply the framework are respected, one should bear in mind that MRAMs aim to inform which combination of projects maximises value (entailing benefits and risks) for the available resources, and that there are two main modelling approaches that can be used: the optimization approach (Bana e Costa and Soares, 2004; Liesiö et al., 2007; Oliveira et al., 2012) and the prioritization approach (Bana e Costa et al., 2006; Phillips and Bana e Costa, 2007).

Nevertheless, prior to the construction of models one needs to understand which aspects need to be considered in these models, which depends on the context and is expected to include organizational areas, audit units, project options, costs, measurement criteria of benefits, risks, synergies and interdependencies between projects and other related aspects (Friend and Hickling, 2005; Keeney, 1992; Montibeller et al., 2009), as well as who should participate in model construction and whom the model is expected to assist.

Figure 2.1 presents the framework that was created to assist auditing organizations in structuring MRAMs, with a set of steps to be followed, and with a wide range of techniques and tools being used to generate relevant information in a structured way in each step, which we briefly describe.

The first step is to identify the type of decision problem and understand the different perceptions of the relevant actors for the decision. The next step seeks to identify the key stakeholders and analyse their power and influence on the decision context. Once the problem and the stakeholders are identified, it is necessary to have an understanding of the goals and values of the stakeholder(s). It follows the identification of decision alternatives, which in auditing context means the identification of audit projects that will be evaluated, is an important step in the structuring process and can be performed through different techniques / tools. Another key step in the process is the identification of the uncertainties that can influence the expected results and should be incorporated into the value model to be constructed. And, finally, it is also necessary to identify constraints that may be relevant for the allocation of scarce resources to competing audit projects.

3.3. Methodological Design to Structure MRAM to assist SFC

3.3.1. Socio-Technical Design

In order to test and validate the developed framework and to generate knowledge on what needs to be considered in the allocation of resources to auditing programmes in SFC, the socio-

technical design shown in Figure 3.1 was defined. We now briefly describe the techniques and methods, as well as the participatory processes that were created for each step.

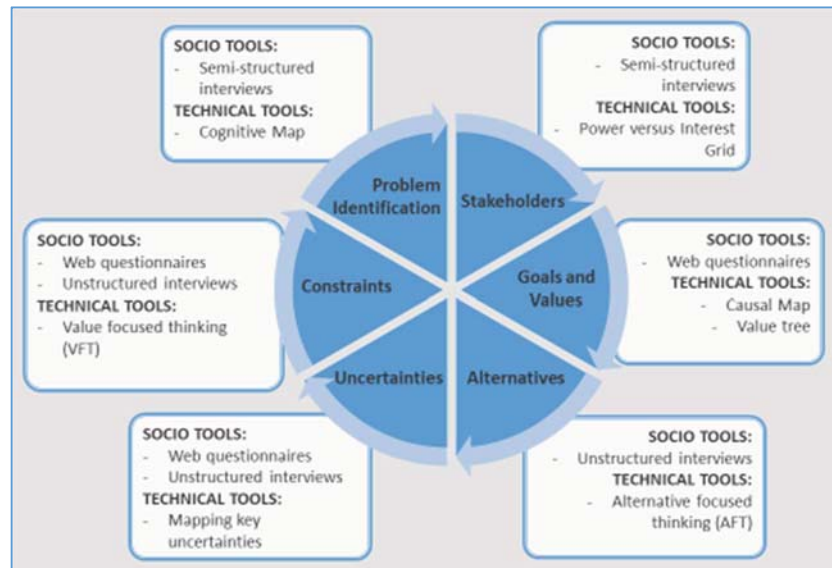


Figure 3.1 – Socio-technical design to structuring MRAM in the SFC Operational Plan elaboration process.

Problem Identification

At first, since the SFC has a specific board of directors for the planning and coordination of audit projects, we established as an articulation point for the case study, the Coordinator for Planning, Evaluation and Monitoring (*Coordenação-geral de Planejamento, Avaliação e Monitoramento – CGPLAM* in Portuguese), subordinated to the aforementioned board of directors. The CGPLAM is responsible for coordinating the procedures and stages in the process of developing the Tactical and Operational Plans, as well as for submitting the process results to the final approval of their superiors. Thus, in this first stage, the CGPLAM was considered a key stakeholder.

In order to identify the decision problem involving the elaboration of the Operational Plan, semi-structured interviews (Bowling, 2009) were elaborated and applied to CGPLAM (Appendix I), to gather the necessary information for the elaboration of the 'Cognitive Map' (Eden, 2004), the technical tool selected in this stage. It is a powerful tool for capturing different aspects of the problem being addressed and useful for clarifying ideas and perceptions of those involved, which presents a graphical representation of thoughts in a network shape and containing nodes and arrows whose direction implies causality (Eden, 2004).

Stakeholders' Identification

The SFC Operational Plan is developed in articulation with the directors, audit coordinators and superintendents of the CGU Regional Offices. Thus, it is necessary to analyse the influence and interest of each one of these CGU members in the plan definition. To this stage, the 'Power versus Interest Grid' (Mendelow, 1981) instrument was selected to understand how the communication and relations between stakeholders can affect the structure of the model and its implementation (Bryson, 2004). This tool helps clarifying the main interests and influences of the parties involved. On the social side of the process, this could be done through semi-structured interviews or questionnaires (Bowling, 2009) with the key stakeholder and other actors involved in the process.

Goals and Values' Identification

The SFC Operational Plan presents the set of audit projects that will be executed during the year of its validity. Audit coordinators and superintendents of CGU Regional Offices have the freedom, within the limits of the guidelines defined by the board of directors, to propose the auditable objects to be included in the plan, according factors that they consider relevant.

Here, we attempt to identify the factors considered by the stakeholders when proposing a project to integrate the SFC Operational Plan, by developing a 'Web Questionnaires' application (Bowling, 2009; Neuman, 2013). Figure 3.2 shows screens of such questions on the applied questionnaire. The complete questionnaire in portuguese is in the Appendix II. As technical tools, we considered the representation within a 'Value Tree' (Goodwin and Wright, 2005) and within a 'Causal Map' (Montibeller and Belton, 2006). The value tree displays the family of key concerns in a tree-shaped and provides a panoramic view of key objectives at different specification levels. The causal map, in turn, graphically represents a network of interconnected concepts (ideas) through the means-ends structure, where decision options are a means of reaching the goals of decision-makers (Montibeller and Belton, 2006).

Part 1. Identification of the Operational Plan Objectives	Part 2. Characterization of the projects choice.
<p>1. From your point of view, what are the MAIN OBJECTIVES of the Operational Plan? (max 3 options)</p> <p><input type="checkbox"/> List the control actions (projects) to be performed by the unit in the period.</p> <p><input type="checkbox"/> Firm commitment to the products to be delivered in the period.</p> <p><input type="checkbox"/> Organize the projects to be executed according to the priorities defined by the Tactical Plan.</p> <p><input type="checkbox"/> Direct the allocation of unit's human resources available within the projects.</p> <p><input type="checkbox"/> Support planning and consolidation of work involving more than one performer.</p> <p><input type="checkbox"/> Have an overview of the public policies of my area / region.</p> <p><input type="checkbox"/> Enable the achievement of the CGU's strategic objectives.</p> <p>Other(s). To specify:</p> <p>_____</p>	<p>2. What are the MAIN FACTORS that should be taken into account when defining which project will be proposed in the Operational Plan, considering the auditable objects mapped? (max 4 options)</p> <p><input type="checkbox"/> Institutional priorities defined by the Tactical Plan.</p> <p><input type="checkbox"/> Operational Capacity.</p> <p><input type="checkbox"/> Expected benefits of project execution.</p> <p><input type="checkbox"/> Materiality related to the auditable object.</p> <p><input type="checkbox"/> Necessary skills to carry out the project.</p> <p><input type="checkbox"/> Relevance (government strategy, manager priority, media placement, demand for Defense Organizations).</p> <p><input type="checkbox"/> Criticality (complaints, performance of the CGU, confidential expenses, results of previous work).</p> <p><input type="checkbox"/> Expectation of the results coming from the performance of the internal audit for the society.</p> <p><input type="checkbox"/> Potential of transversality of the performance in other areas.</p>

Figure 3.2 – Web questionnaire screens to support the SFC Operational Plan elaboration process.

Alternatives' Identification

In this step, one can use the 'Alternative Focused Thinking (AFT)' (Keeney, 1992), in which, after defining the problem, the audit projects are identified and then the criteria considered in the evaluation are specified. This is advisable when areas are pre-defined, the initial set of options is stable and new options are unlikely to be included further on in the analysis (Montibeller et al., 2009). Basically, the SFC audit units' structure is divided by thematic areas of public policies and the set of possible lines of action is already pre-established. These lines of action for audit projects range from the Annual Audit of Accounts, Evaluation of the Government Programs Execution, Management Results Evaluation, Audit in Contracts with External Resources, Analysis of Personnel Acts, Verification of Complaints and Social Demands, and so on.

Uncertainties' Identification

Following in the framework stages, in our case study, a survey of the main uncertainties among those involved was carried out through a web questionnaire (Bowling, 2009; Neuman, 2013). Through the questionnaire, respondents were asked to identify which are the most critical and sensitive issues to the planning of audit projects by SFC, and for this no particular technique is used.

Constraints' Identification

To complete the information to be considered in the model, it is also necessary to identify the constraints that exist to the choice of audit projects and to the allocation of resources. In order to identify the constraints involved in the process of elaborating the SFC Operational Plan, also a web questionnaire was used among those involved (Bowling, 2009; Neuman, 2013). In the context of structuring MRAM it is already expected that there are restrictions regarding the limitation of resources, but through the questionnaires, other restrictions related to the SFC Operational Plan may arise.

3.4. Results

We herein present the main results from applying all the socio-technical steps to the case study. In the Problem Identification step, considering the information gathered in the semi-structured interviews, a 'Cognitive Map' was elaborated depicting an overview of the current process to elaborate the SFC Operational Plan, as shown in Figure 3.3.

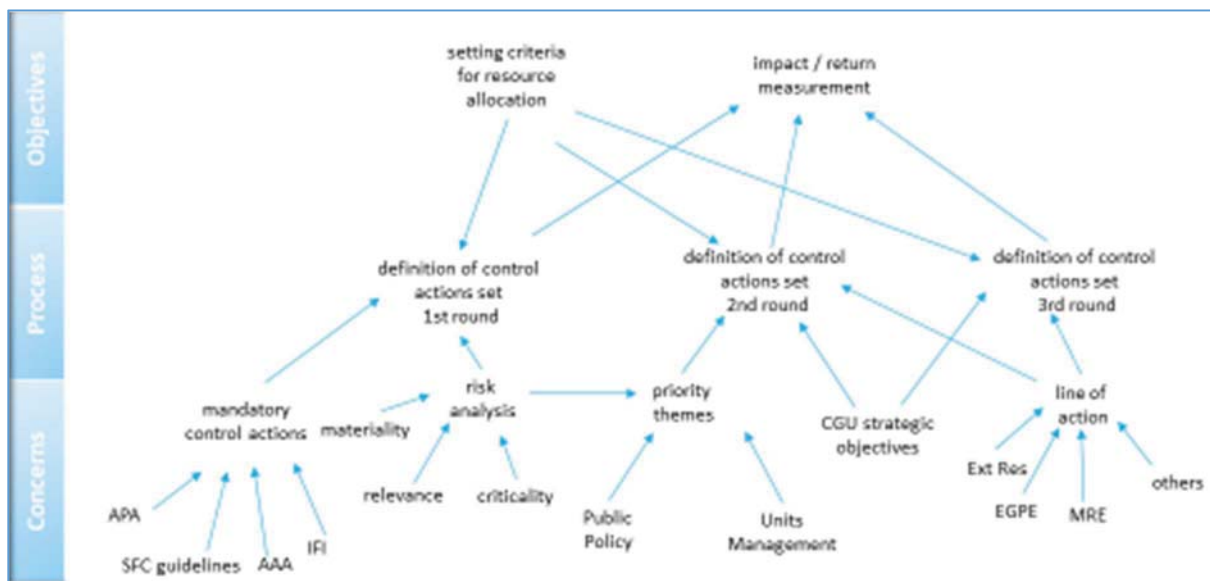


Figure 3.3 – Cognitive Map for the current SFC Operational Plan elaboration process.

In the next stage, through the semi-structured interviews, the key stakeholders were identified and the 'Power versus Interest Grid' shown in Figure 3.4 was produced. The audit coordinators and superintendents are responsible for proposing projects to compose the Operational Plan and they have

high power and influence on the process. Conflicts of interest are submitted to the board of directors for final decision. The political agents are responsible for creating the Public Policies that will be included in the themes to be prioritized by the board of directors, which will subsidize the elaboration of the Operational Plan. They have high power of influence but are not directly interested in the SFC Operational Plan. In turn, the CGU analysts are bound to the plan guidelines during the execution of their work and the auditees are likely to be directly affected by these audit projects, which make them stakeholders with low level of influence, but with a high level of interest.

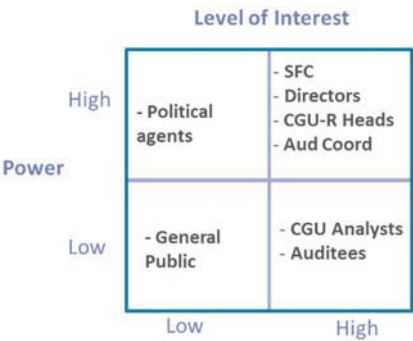


Figure 3.4 – Power versus Interest Grid in the SFC Operational Plan elaboration process.

At the Goals and Values Identification, the main issue is centred in capturing perceptions of the problem, goals and potential courses of action. Taking into consideration the results obtained in the previous steps, the web questionnaire was developed and applied to a universe of 200 stakeholders (directors, audit coordinators, team leaders, superintendents). As a result, 72 responses were collected, corresponding to a sample with a result with 95% confidence level and 9% of error margin. More than 55% of respondents indicated that the main objectives of the SFC Operational Plan are: organize the projects to be executed according to the priorities defined by the board of directors; firm commitment with the results to be delivered in the period; and, make possible the achievement of the strategic objectives of the CGU. The results of the questionnaire responses are consolidated in Appendix II.

When we analysed the responses separately for each group of stakeholders – for directors, superintendents, audit coordinators and audit team heads – we found out differences in their perspectives. While the directors and audit team heads followed the priorities listed in the respondents' overview, the audit coordinators consider that the focus of the Operational Plan lies in the execution of the audit project and results delivery, diverging from the superintendents, who focus

the Operational Plan on the achievement of CGU strategic objectives, according to the allocation of available human resources. These facts can be observed in the graph shown in Figure 3.5.

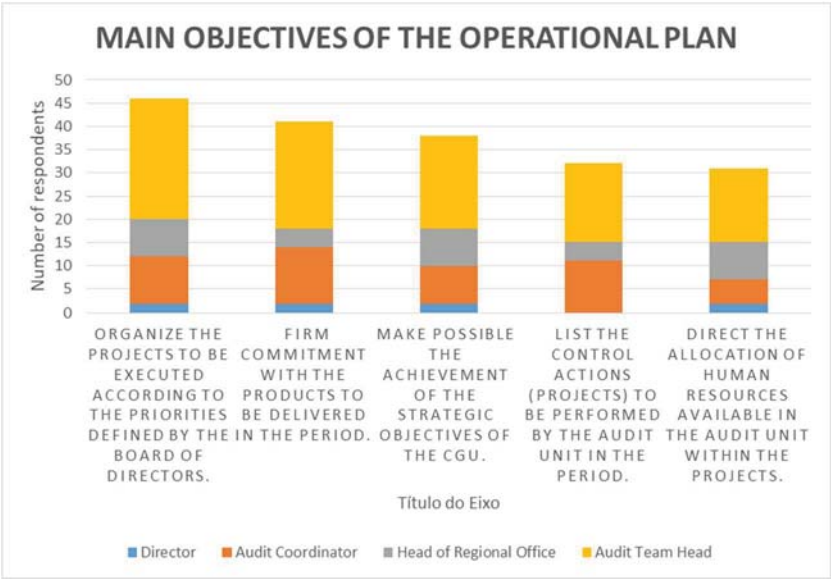


Figure 3.5 – Web questionnaire answers related to SFC Operational Plan objectives.

Still from the respondents’ answers, a causal map was created to help capture the main objectives of the problem and clarify the set of potential strategic options, as shown in Figure 3.6. Each node represents a concept (or idea) and a connection between two nodes represents causality, influence or implication. A positive sign indicates a positive connection.

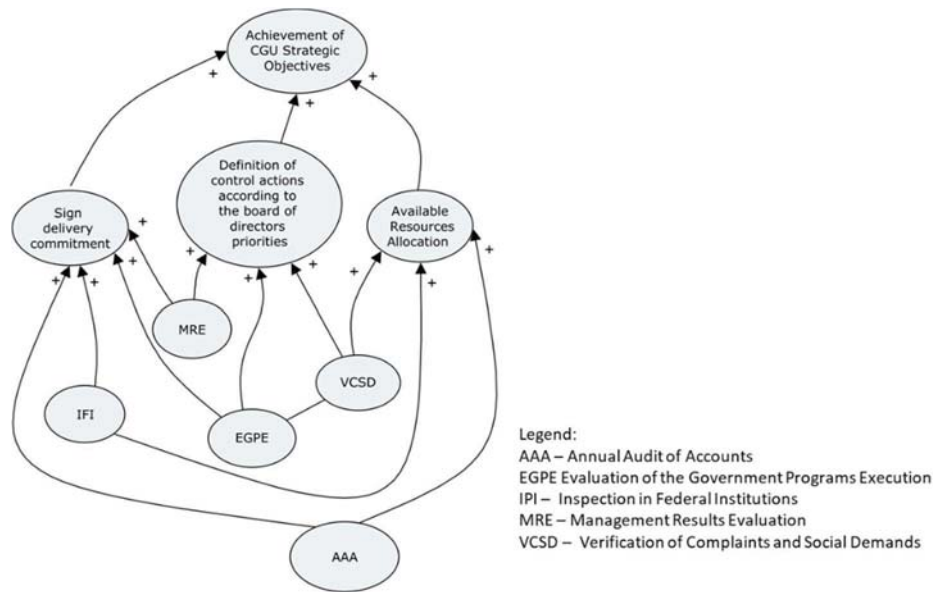


Figure 3.6 – Causal Map for the SFC Operational Plan elaboration process.

Also in this stage were captured the main choice factors considered by the stakeholders when they propose an audit project. These factors compose the criteria set in the value model building for the evaluation of the audit projects that may compose the portfolio that are deemed as relevant by the stakeholders, and are depicted in a value tree format, for two type of stakeholders views: audit coordinators and superintendents (once directors and audit team heads followed the respondents' coordinators perspective). We could conclude that different perspectives can lead to different choices of audit projects according to these perspectives, as shown in Figure 3.7.

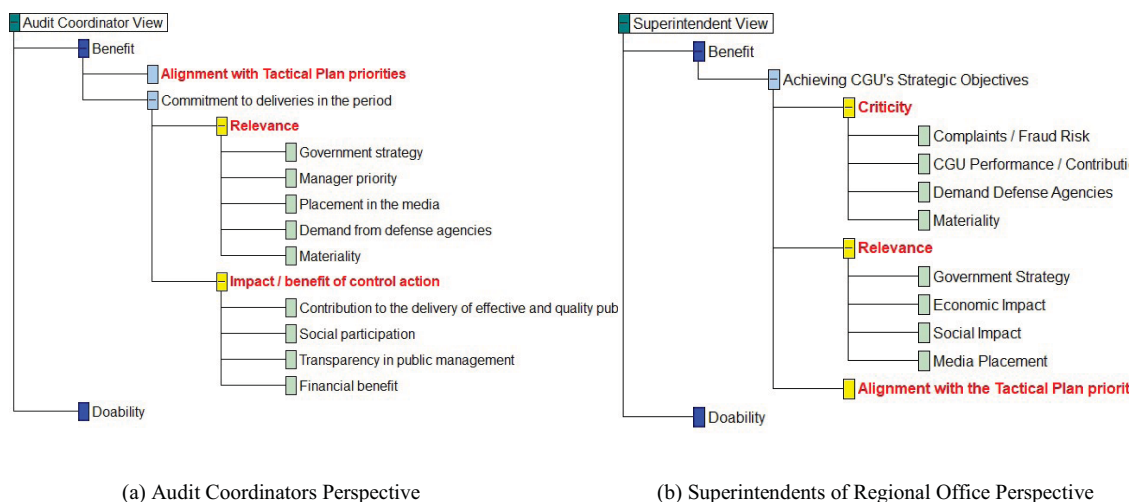


Figure 3.7 – Value Tree for audit project assessment in the SFC Operational Plan elaboration process according to the stakeholder group perspective.

In the Alternatives' Identification step, the potential audit projects to compose the Operational Plan were identified. The audit projects proposed in the Operational Plan should follow the board of directors' guidelines and generate results that contribute to the achievement of the CGU strategic objectives. Considering the SFC organization form by areas, AFT concept was used to list the alternatives. This were done through interviews and questionnaires with key stakeholders. As a result, we find that the main projects that consume most of the audit units' operational capacity were in these lines of action: Annual Audit of Accounts (AAA); Management Results Evaluation (MRE); Evaluation of the Government Programs Execution (EGPE); Verification of Complaints and Social Demands (VCSD); and Inspection in Federal Institutions (IFI). Thus, these are the audit projects that should be evaluated in the value model.

Regarding the Uncertainties' Identification, Figure 3.8 presents the consolidation of the questionnaire answers about the uncertainties. Over 50% of respondents considered that the main uncertainties are related to: measurement of the costs involved in each audit project, whether in terms of work effort (operational capacity) or other resources (logistics, specialists, etc.); the arising of extraordinary demands; the availability of appropriate expertise in the audit team; and the measurement of expected benefits (impacts) of audit projects.

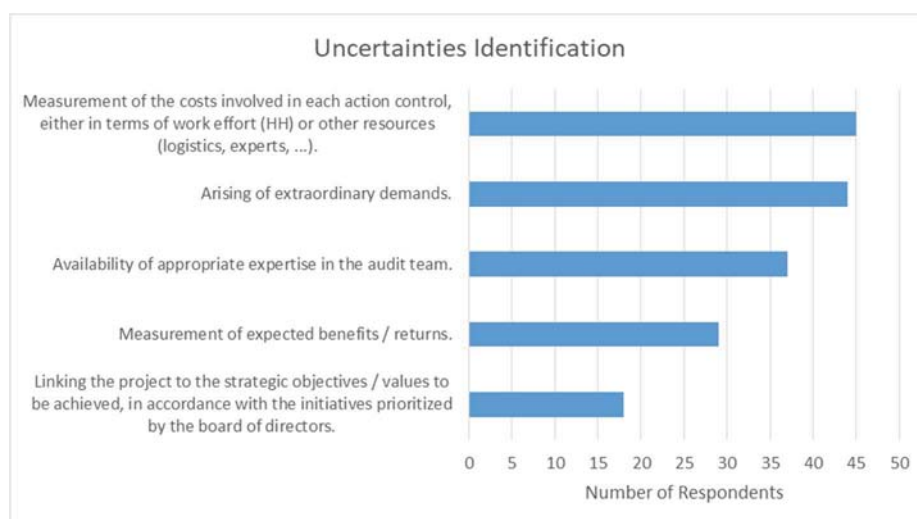


Figure 3.8 – Web questionnaire answers related to uncertainties identification.

Finally, regarding the identification of constraints, we realized that the main constraints involved in the SFC Operational Plan elaboration process were resource constraints, synergies between projects and interdependencies between projects.

A final and important step to be followed after collecting all the data is the validation of the collected information with the key stakeholders, which in the case study are the director of planning and the coordinator of CGPLAM. This validation was performed through unstructured interviews.

3.4.1. Results' Synthesis

Results from applying the framework in the CGU case show that the structuring process implies that:

- in a broad outline, there is a need to develop tools to inform the allocation of limited resources to audit projects;
- the key stakeholders involved in the process are those with high power of influence and interest, namely directors, audit coordinators, superintendents of Regional Offices and audit team heads;
- there are two groups of interlocutors (audit coordinators and superintendents) who differ slightly on the main factors that should be considered when evaluating an audit project to compose the Operational Plan. Consequently, a joint model is required to compare with models for these two groups;
- the different objectives to be achieved according to each stakeholder group and that should be considered in MRAMs are reflected in the value trees presented in Figure 3.7.
- the main uncertainties are related to the measurement of costs and technical skills required in the audit projects, as well as the measurement of the impacts of audit projects. So, it is necessary to model the required resources, which could be done by studying the 'doability' of audit projects (Bana e Costa et al., 2014), which means, in general lines, to perceive the difficulties and / or obstacles in implementing one of these projects;
- the types of constraints regarding audit projects consider resource constraints, but also identify audit projects with synergies and interdependencies. This implies that the use of optimization approaches is recommended and should be considered in the models.

Thus, the MRAM should be designed to consider these aspects to aim effectively assist CGU decision-makers.

3.5. Discussion

Dealing with a multicriteria resource allocation situation, one must define all the necessary information to build the model to select the best portfolio to organization's interests. There are several MRAMs in literature but the choice of which to use depends on the context to be addressed. Thus, in our case of study, to select the audit projects to compose the SFC Operational Plan, it is first necessary to identify the objectives, the stakeholders, the factors that should be considered when evaluating the alternatives (in this case already pre-defined), as well as the uncertainties and constraints involved.

The application of the framework shows that it can be very useful in the structuring of resource allocation models in the audit context. Thus, by going through all steps of framework one can get all the necessary information to structure the value model to assess the audit projects that will generate the best portfolio to compose the Operational Plan. Additional work can be done to structure not only the financial cost but the ability of the services to audit, which requires specific metrics such as measuring doability, as well as measuring the expected benefits (impacts).

Regarding to the social aspect of this participatory process, it was perceived the commitment of those involved in the process, while at the same time they aim for structuring instruments that bring transparency and systematization to the process. It is worth mentioning that the authors received positive feedback from the participants, who considered that this study has potential to reflect in improvements in the decision-making processes for allocating CGU resources.

Further work is needed to apply the framework to other contexts, especially those that involve conflicts of interest or those that require the application of other framework tools and techniques not used in this case study. So, in the presence of conflicts of interest, adaptations to the models and application of complementary negotiation tools may be necessary.

Therefore, in CGU case presented, the application of the framework evidenced the presence of groups of decision-makers with different perceptions about how to evaluate audit projects, leading to the need to build representative models for each group. Thus, there is a need to develop other instruments to support the definition of audit project portfolios. In the next chapter, we will show how to enhance multicriteria resource allocation decisions in auditing context, integrated with negotiation tools, to assist decision-makers in the selection of audit projects.

Chapter 4 ENHANCING MULTICRITERIA RESOURCE ALLOCATION WITH NEGOTIATION TOOLS TO ASSIST DECISION-MAKERS IN THE SELECTION OF AUDIT PROJECTS

In this chapter we propose a methodology to enhancing multicriteria resource allocation decisions in the auditing context, integrated with negotiation tools. Actually, the Comptroller General of the Union (CGU) deals with groups of stakeholders that need to work on a common and transparent basis, and negotiate towards the choice of a portfolio of audit projects that compete for resources. CGU is thus under a multicriteria resource allocation context (with projects aiming to achieve several objectives) in which a negotiation process is necessary. This study aims to contribute to literature by integrating negotiation and bargaining steps within Portfolio Decision Analysis (PDA) modelling in an audit context. Specifically, it designs and tests a socio-technical approach, based upon multicriteria resource allocation techniques, to support the selection of audit projects. The socio-technical approach was applied in a real case study, namely the elaboration of Operation Plan in the Comptroller Department of CGU (*Secretaria Federal de Controle Interno – SFC* in Portuguese). At the end of the negotiation, the stakeholders were able to reach a compromise solution on the project portfolio, supported by an informed negotiation framework, as well as provided positive feedback regarding their experience with the process and tools in use and regarding the relevance of its adoption by CGU.

4.1. Introduction

The CGU, through its Comptroller Department (SFC) and with the aid of the Offices in the Regional Units, evaluates the execution of government programs, checks the compliance with legislation, checks the efficiency of the management of federal public administrators, and also controls credit operations. CGU's activity areas involve distinct management and public policies themes (i.e. health, safety, infrastructure, education, etc.), which means that there are multidisciplinary teams with different technical skills involved in CGU decision-making. Its mission is achieved through the execution of audit projects.

In order to plan which audit projects will be performed by the auditors during each year, SFC managers prepare their annual Operational Plan, which contains the audit projects to be performed by the audit teams. One of the most important challenges is to be able to compare the audit projects proposed and executed by these teams on a common base, following a transparent, well-informed and fair resource allocation process. This allocation of resources is not a simple task, with conflicts of interests among stakeholders often arising and with negotiations and compromise solutions being searched. Thus, decisions on programs selection need to be supported on a common and transparent evaluation of projects, while taking into account and reconciling the different views within an integrative negotiation process.

In this sense, within a negotiation perspective, the central issue is: how to select the audit projects to compose the Operational Plan, considering different views of stakeholders?

Up to our knowledge, there is little literature integrating negotiation with PDA, and such literature does not exist in the auditing context. This study aims to fill these gaps by integrating negotiation within PDA modelling in an audit context. Specifically, it designs and tests a socio-technical approach, based upon multicriteria resource allocation techniques, to support different groups of auditing stakeholders in the selection of audit projects. The proposed socio-technical approach combined sound tools with specifically designed participatory processes, so that multicriteria resource allocation tools can effectively assist stakeholders in selecting audit projects within a negotiation perspective.

Our proposal of methods is not prescriptive nor descriptive, but constructive. I.e., using the concept of design research (Collins et al., 2009) to design and test methods, with the effective participation of those involved, in a multicriteria resource allocation process and following the views of the constructivist school of socio-technical thinking (Bana e Costa and Pirlot, 1997), supported by an consultant/facilitator that *“guides the group in how to think about the issues, not what to think, which is the responsibility of the participants”* (Phillips and Bana e Costa, 2007, p.55). Thus, the resource allocation challenge at CGU (and the solution) belongs to the decision-maker and not to the decision analyst/facilitator. In this sense, we can also highlight that one of the important innovations of the study is to reduce the distance between theory and practice in the development of methods in a real context, bringing knowledge and development and process improvement into an organization. In this way, we have a real-world situation to be addressed, supported by sound scientific methods and with a high interest from CGU decision-makers, as well as a contribute to the negotiating,

multicriteria decision analysis (MCDA) and PDA literatures. We specifically attempt to contribute to the literature by integrating the perspective of negotiation into the PDA context.

In the next section we retrieved studies from the literature (related to MCDA, PDA and negotiation approaches) that can aid the construction of our socio-technical process, and frame our proposal of methods. In section 4.3, we describe our methodological proposal. In section 4.4, we report the real case study in which the proposed methodology was applied at CGU to select audit projects. We report the views from participants regarding the process and results from applying the proposed methodology. Finally, in the section 4.5, the methodology and results are discussed and final remarks are presented.

4.2. Literature Review

Taking a constructivist view in MCDA (Bana e Costa and Pirlot, 1997; Lee, 2012; Peterson, 2012) in that research is performed with the collaboration of participants/evaluators and accepts that *“a decision situation is, in general, an ill-defined entity, unclear even to the actors involved in the decision process”* (Bana e Costa and Pirlot, 1997, p.564), our review of studies started by searching studies that report multicriteria evaluation models and tools to evaluate projects and that use some type of negotiation instrument to deal with divergent opinions. Our search protocol focused on combinations of several keywords – negotiation, group decisions, conflict analysis, disagreement, MCDA, PDA, integrative negotiation, auditing – in the data sources B-on; Web of Science; ScienceDirect; SCITEPRESS Digital Library. This review analyses 47 studies published between 1982 and 2017. Surprisingly, a small number of studies filled these search criteria. These studies typically make use of multicriteria resource allocation and of multicriteria portfolio decision analysis models and explicitly make use of some type of negotiation or consensus building mechanism, which are key features for models to inform the selection of projects when there are scarce resources and individuals need to be involved. It is noteworthy that there may possibly be other studies that were not caught in our protocol. Before introducing these studies, we present key concepts.

4.2.1. Concepts

We begin by highlighting the elementary principles of building decision support models that are key for multicriteria modelling. From the perspective of MCDA, one can say that evaluation models for decision support require three interactive phases (Bana e Costa and Beinart, 2005): (i) the structuring

of the decision-making context; (ii) the construction of evaluation model; and (iii) impact assessment and analysis. The structuring phase requires understanding the problem and the decision context. To achieve this, a representation in the form of a hierarchical value structure commonly named as a value tree – accepted and negotiated by all stakeholders – is constructed (Keeney, 1992). This tree should represent, in an organized way, the dimensions of values and key-concerns that are relevant to the evaluation process and according to which the options/projects/programs/actions will be evaluated. In the evaluation phase, a mathematical evaluation model (most commonly an additive value model), through which options are evaluated, is constructed. The impact assessment phase is sought to provide those developing the model with the analysis of the consequences of implementing each one of the options considered, with model adjustment and validation procedures being also used, beyond sensitivity and robustness analysis (Bana e Costa and Beinat, 2005).

In turn, in cases of limited resources one is dealing with portfolio problems and Portfolio Decision Analysis (PDA) is applicable. According to (Salo et al., 2011, p.4), PDA means *“a body of theory, methods, and practice which seeks to help decision-makers make informed multiple selections from a discrete set of alternatives through mathematical modelling that accounts for relevant constraints, preferences, and uncertainties”*. As emphasized by (Salo et al., 2011, p.3, p.4), PDA can be seen as an *“application of decision analysis to the problem of selecting a subset or portfolio from a large set of alternatives. PDA has a sound theoretical and methodological basis, and its ability to contribute to better resource allocation decisions has been demonstrated in numerous applications. PDA follows the tradition of decision analysis (and, more broadly, of operations research) in that it seeks to improve decision making by using mathematical models in the development of decision recommendations”*. PDA focuses on portfolio choice (as opposed to the choice of a single alternative from a set) by appraisal of options across many issues and finding the best combinations of options for a given level of resources (Phillips and Bana e Costa, 2007).

4.2.2. MCDA and PDA with Conflict Analysis

When one comes across a real situation of audit project selection to compose a portfolio, we need mechanisms to evaluate these projects in multiple dimensions and this has been done by MCDA literature – more specifically by multicriteria PDA literature – applied to real situations, whose models have a potential to help building multicriteria models (some examples are (Bana e Costa, 2001; Bana e Costa et al., 2001; Mateus et al., 2017; Oliveira et al., 2012)) in the auditing context. Similar to most studies in the area, we suggest making use additive value models to evaluate audit projects. It is worth

mentioning that under the presence of divergent views, the models should reflect the different opinions of the decision-makers' groups (or stakeholders, or those involved in evaluation) and make use of well-designed participatory processes that promote convergence of opinions (Phillips and Bana e Costa, 2007); and that when one identifies non-additive cases, models should be restructured so that additivity conditions are respected (having additive models the advantage of being transparent and better understood by evaluators and stakeholders).

Seeking for applications of MCDA under conflicting situations, various approaches and techniques for dealing with divergent opinions or views have been proposed. At this point, it is interesting to note that divergent opinion should not be confused with conflict of interest. The former does not necessarily indicate a conflict situation. Conflicts usually emerge in situations where it is not possible to satisfy all the objectives of all parties involved (Losa and Belton, 2006) because of unbalanced (attractive and unattractive) consequences. On the other hand, divergent views can just reflect different actors' goals. In situations of conflict of interest, it is worth bringing those involved together to build a unique value model for dealing with the trade-offs. However, depending on the context, especially when it is not possible to bring all involved together to build just one common model, it is more enriching to put stakeholders to model value separately and then to negotiate.

Bana e Costa (2001) explored the use of MCDA to support the search for less conflicting policy options. The author highlighted that public resource allocation often requires the management of conflicting objectives of multiple policy actors at different spatial levels. The mix of limited financial resources, multiple and conflicting concerns, spatial variability of policy impacts and several types of uncertainty in the data available for policy evaluation, made this process problematic. In this case, conflict analysis was based on the spatial analysis of the results of the value model. Bana e Costa et al. (2001) presented a case study of conflict dissolution in the public sector through identification of the fundamental points of view characterising the different value systems of the stakeholders. The authors brought a pre-negotiation approach aiming to dissolve the conflict in an enlarged frame. Impact assessment revealed the conflicting nature of the alternatives. The authors then engaged the planners in a decision-analysis process oriented towards the generation of win-win solutions – to dissolve the intrinsic value conflict.

Losa and Belton (2006) brought an exploratory application of an integrated approach, combining MCDA and conflict analysis. They have integrated Drama Theory and MCDA to model the situation using confrontation analysis with the following elements: characters, actions, positions and fallbacks,

and preferences. The resolution of the conflict consisted of detailed analysis of the characters positions, threats and dilemmas, through a multicriteria evaluation of the different futures.

Also worth mentioning is the use of the MACBETH (*Measuring Attractiveness through a Category Based Evaluation TechNique*) approach, that only requires qualitative judgments about differences in attractiveness to build a multicriteria value model (Bana e Costa et al., 2012), and has been used for consensus generation when different perspectives arise. Specifically, two studies reported the use of a “MACBETH Voting” decision support system (DSS) to promote convergence and compromise in model building. “MACBETH Voting” is characterised by using the MACBETH (intuitive) qualitative questioning protocol together with voting procedures that potentiate convergence of views in a decision conferencing environment in which key stakeholders physically meet (Bana e Costa et al., 2014; Mateus et al., 2017). In these studies, a unique value model was built to support group decision and reach compromise solution.

Mateus et al. (2017) describe a real-world application of MCDA and related DSSs (M-MACBETH, MACBETH Voting, and Web-MACBETH) to support the engagement and participation of a group of key players. Two alternative multicriteria aggregation schemes were applied in order to assist the group in evaluating the added value and doability of the proposed actions. New measures and methods to analyse the dominance relationships between the actions were proposed, further assisting the group in the priority selection of the most effective and doable actions.

Fasth et al. (2016) presented a method based on disagreement constrained project selection in participatory PDA. They investigated the stakeholders' disagreement with regard to each project, and how portfolios can be generated that elucidate how conflicting preferences affect the portfolio composition. Their method for participatory PDA consisted on: eliciting stakeholder preferences; measuring stakeholder disagreement; disagreement constrained portfolio generation; and sensitivity analysis.

Salo (1995) developed an interactive approach for the aggregation of group members' preference judgements and presented joint preference representation in the form of value trees that conveys areas of conflict and disagreement. Vilkkumaa et al. (2014) described a multicriteria portfolio modelling for the development of shared action agendas in group decision and negotiation. When seeking for consensual compromise solutions, non-dominated portfolios with a high acceptability index are viable candidates because they contain topics that are in the core or borderline for many group members.

From the above, we can make use of multicriteria models to elicit stakeholder preferences, evaluate projects, generate portfolios, and analyse how divergences or conflicts of interest can be overcome.

4.2.3. Negotiation

Moving towards studies focusing mainly on the group decisions and negotiation process, as emphasized by Vetschera (2013), negotiations are one means of resolving conflicts. Negotiation depends exclusively on the parties involved and on their attempt to reach an agreement that is acceptable to all parties. Negotiation can be seen from a prescriptive-descriptive perspective, where rationality of the negotiator is supported by prescriptive theories such as game theory and, on the other hand, actual human behaviour is considered (Raiffa, 1982). Therefore, a negotiation can be seen as a process at the group level, in which those involved influence each other and try to converge toward some point of agreement. The author points out that negotiation processes can be based on concessions, in which each party begins from a desirable position and over time reduces its demand until a point considered satisfactory for both parties and an agreement is found. Alternatively the parties can start from a solution which is not attractive to either party, and jointly look for improvements, as in single negotiation text (SNT) type of negotiation (Raiffa, 1982).

Keeney (1992, p.258) also suggested procedures for empathetic negotiation within a value focused thinking frame: *“view the situation from the perspective of other stakeholders; structure his values as much as possible; begin by identifying the negative impacts of your desired alternative relative to the status quo in terms of his values; follow their implications through a mean-end objectives network to the fundamental objectives of the stakeholder; create modified alternatives that can at least improve matters in terms of these objectives while maintaining the key consequences desired by you”*. In the end, the goal is to create an alternative that both parties win.

In an integrative negotiation process, as explained by Sarabando et al. (2013), successful strategies include cooperation, information sharing and joint resolution of problems. Mediation and arbitration are particularly useful in integrative negotiation, since they can help negotiators to identify potential areas of improvement for both sides. A value-based evaluation model allows each party to evaluate their potential own proposals, proposals made by the other party, and their BATNA (best alternative to a negotiated agreement). In the negotiation, it is important to bear in mind the desirability of the best alternative to a negotiated agreement (BATNA). According to Keeney (1992, p.238) *“this alternative indicates your power in a negotiation, as there is no reason to consider*

alternatives less desirable than your BATNA". The author also highlighted that can be useful to understand the BATNA values of the other stakeholders, because this can indicate their relative power and goodwill to negotiate. So, *"the alternatives that are most desirable to create are those that are better than the BATNA alternatives for all of the stakeholders"* (Keeney, 1992, p.238).

Filzmoser and Vetschera (2008) highlighted the bargaining process that can be seen as a sequence of offers and often, formal models of negotiation processes based on theories such as game theory or decision analysis focus on the exchange of offers. Greenhalgh and Chapman (1998) showed that information sharing could facilitate joint gain because negotiators disclose and learn about the interests of each party, providing integrative bargaining.

From the above, making use of these concepts, as we are dealing with negotiation, there may additionally be uncertainty, and one can make use of the utility concepts instead of value, but with similar analyses and logic applying. In terms of bargaining, as highlighted by Filzmoser and Vetschera (2008), a negotiator can increase demand, reduce it, or leave it unchanged. The authors grouped possible patterns into four categories – concession, trade-off, insistence and demand –, using the following notation: offers of a negotiator are indexed by a time index t . The value of issue k in offer t is $x_{k,t}$, and $u_k(\cdot)$ is the negotiator's marginal utility function for issue k . They called a *"bargaining step a concession, if $u_k(x_{k,t-1}) \geq u_k(x_{k,t})$ for all k and $u_k(x_{k,t-1}) > u_k(x_{k,t})$ for at least one k . A concession therefore is a sequence of two offers where the negotiator chooses an inferior value in one or more issues but does not improve his or her position in any issue."* Thus, from a negotiator's point of view, when he makes a concession, this offer is dominated by his previous offer. In turn, a *"bargaining step is called a trade-off, if $u_k(x_{k,t-1}) > u_k(x_{k,t})$ for at least one k and $u_k(x_{k,t-1}) < u_k(x_{k,t})$ for at least one other k . A trade-off in this context is therefore a sequence of offers where the negotiator lowers the demand in at least one issue and at the same time increases the demand in at least one other issue, possibly leaving some issues unchanged."* Although the other types of bargaining steps can also occur in single-issue negotiations, trade-offs only make sense in multi-issue negotiations. They also called a *"sequence of two consecutive offers of one negotiator insistence if $u_k(x_{k,t-1}) = u_k(x_{k,t})$ for all k . An insistence is therefore a sequence of offers where the negotiator does not change the position in any issue or chooses values with the same utility."* Finally, the authors called a *"sequence of two consecutive offers of one negotiator demand if $u_k(x_{k,t-1}) \leq u_k(x_{k,t})$ for all k and $u_k(x_{k,t-1}) < u_k(x_{k,t})$ for at least one k ".* The authors point out that a demand is quite the opposite of a concession, that is, a sequence of offers in which the negotiator maintains a preferential value in one or more issues and

does not accept a lower value in any issue. Thus, on demand, the offer presented dominates the negotiator's previous offer. (Filzmoser and Vetschera, 2008, p.426).

Górecka et al. (2016) presented an approach in the verbal and holistic evaluation of the negotiation template to evaluating negotiation offers when the negotiator's preferences are expressed verbally. Present Measuring Attractiveness near Reference Situations (MARS) approach, these authors combined the algorithms of two multiple criteria decision-making methods: ZAPROS and MACBETH. They also suggested a pre-negotiation preparation, with a negotiation template, designed and evaluated by means of the negotiation offer scoring system. The problem of evaluating the negotiation template from an individual negotiator's viewpoint is similar to a decision-making problem with multiple criteria involved and negotiation offer scoring system was modelling as a simple additive value method.

Tajima and Fraser (2001) proposed a quantitative method which produces Pareto optimal solutions through the integrative negotiation strategy, jointly improving exchange of issues using logrolling, in which loss in some issues is traded for gain in others, resulting in overall gain for all parties. As authors highlighted, *"when incorporated in a negotiation process, the integrative approach helps avoid settling for non-Pareto optimal solutions by seeking mutually beneficial solutions for all parties involved. It also focuses on individuals and their gain, and hence, avoids negative connotations such as sacrifice and concession. Moreover, it focuses on the added value increase for each party, which is likely to be interpreted as an incentive for all parties to comply"* (Tajima and Fraser, 2001, p.218). They also emphasized the trade-off methods based on integrative approach that can be characterized as successively generate jointly improving negotiation proposals from a non-Pareto optimal alternative toward a Pareto optimal alternative through issue trade-offs. The Single Negotiation Text (SNT) can be considered an example, in which the parties examine a solution which is not attractive to either party, and jointly look for improvements, producing a series of SNT's, *"which are jointly improving, and ends when all parties accept one SNT as their final agreement"*.

In addition to the above, it is important to keep in mind, when entering into a negotiation, some key tactics for success in a negotiation, namely the psychological tools that should be known to avoid traps. Bazerman and Moore (2009) brought some of these negotiation tools that can be very helpful in our context. They cited 'Mythical Fixed Pie Assumption' – when one assume that his interests are in direct conflict with the interests of the other side but, in fact, perhaps there are opportunities to build a larger pie and this can be no conflict in interest at all. They also highlighted 'Overconfidence', 'Anchoring' (when estimating the value of uncertain objects anchor on an initial value) and 'Framing',

clarifying that the way that options are framed cause us to be risk averse (if positive frame) or risk seeking (if negative frame) (Bazerman and Moore, 2009). Another psychological trap that is worth mentioning is ‘Availability’, in which one is influenced by information that is most easily available (Tversky and Kahneman, 1973).

Thus, this review shows that by combining multicriteria methodology with negotiation tools and techniques, it is possible to build multicriteria resource allocation tools that support the negotiation process, and there is opportunity to develop an informed negotiation framework. Thus, in order to structure our negotiation framework, we will use a multicriteria PDA methodology to construct the audit projects’ evaluation models. Further, given the different perspectives and views (for instance, on graphics of benefits and doability) of each decision-maker or group, in the context of our study at CGU we will combine negotiation (Sarabando et al. 2013) and conflict resolution (Bana e Costa, 2001) techniques to reach a valuable solution and commitment for those involved. Table 4.1 summarizes key aspects from the reviewed studies that may be specifically useful to the design of inform and tools to assist the selection of audit projects in the presence of divergent opinions and of resource constraints. What one can extract from the reviewed studies are multicriteria concepts and techniques applied in conflict situations, as well as negotiation concepts that could be applied in the context of portfolio analysis.

Table 4.1 – Key aspects from reviewed studies.

Reference	Main Field of Knowledge	Area of study application	Study features with special relevance for a negotiated selection of audit projects
Keeney (1992)	MCDA Negotiation	Conceptual examples	Concepts for an empathetic negotiation. Structuring values in mean-end objectives network.
Salo (1995)	MCDA Group decisions	Marketing and production	Joint preference representation and dominance concepts. Value tree
Greenhalgh and Chapman (1998)	Integrative bargaining Negotiation tactic	Laboratory study	Cohesive relationships encourage information-sharing and discourage use of coercive tactics. Integrative bargaining.
Bana e Costa (2001)	MCDA Resource Allocation	Public sector (road-links)	Conflict analysis based on the spatial analysis of the results of the value model. Structuring multicriteria resource allocation model.
Bana e Costa et al. (2001)	MCDA	Transport planning	Value systems of the stakeholders. Pre-negotiation Conflict dissolution through ‘win-win’ compromise solution.
Tajima and Fraser (2001)	Integrative negotiation	Conceptual examples	Integrative negotiation strategy and jointly improving exchange of issues using <i>logrolling</i> .
Losa and Belton (2006)	MCDA Group decisions	Analysis of conflicts in a social service	Conflict analysis. Integrated use of Drama Theory and MCDA.
Filzmoser and Vetschera (2008)	Bargaining process Offers	Electronic negotiations	Develop a typology of bargaining steps for multi-issue negotiations
Vetschera (2013)	Negotiation Offers	Conceptual examples	Survey of process models of negotiations. Concession-based negotiation. Improvement-based negotiation

Sarabando et al. (2013)	Integrative negotiation	Conceptual examples	Integrative negotiation. Value-based evaluation model. BATNA (best alternative to a negotiated agreement)
Vilkkumaa et al. (2014)	PDA Group decisions	Agenda building (wood products)	Interactive decision process. Group members' preferences synthesized into shared priorities for action topics.
Fasth et al. (2016)	PDA	Urban planning	Disagreement constrained portfolio generation.
Górecka et al. (2016)	Negotiation offer scoring system	Conceptual examples	Pre-negotiation: negotiation template, designed and evaluated by means of the negotiation offer scoring system.
Mateus et al. (2017)	MCDA Group decisions	Brownfield	Evaluating the added value and doability of the actions. Application of MCDA and related DSSs to support the engagement and participation of a group of key players.
Bazerman and Moore (2009)	Decision Making Negotiation	Judgment in managerial decision making	Key issues that affect negotiator cognition

4.3. Methodological Proposal

Our methodological proposal is based on the constructivist epistemology (Lee, 2012; Peterson, 2012), that involves research in collaborating with participants and accepts reality as a construct of human mind interacting with experience in the real world. Thereby, before presenting the methodological proposal developed in this study we bring the situation that inspired the need for integration between MCDA and PDA with negotiation, as already reported, the CGU faces the scenario of resource constraints to finance its audit projects (which leads to the context of portfolios analysis).

4.3.1. CGU Decision Context

In a previous study, in order to improve the current process of elaboration of the SFC Operational Plan, a socio-technical process was designed – in which MCDA methods were combined with participatory approaches (Phillips and Bana e Costa, 2007) – in the sense of mapping and capturing the perceptions of the stakeholders involved in the process of selection of audit projects, as well as the goals, the potential courses of action and the constraints related to elaboration of the SFC Operational Plan. We make use of the results of this study to contextualize and frame the proposed methodology.

Specifically, as detailed in Chapter 3, a web questionnaire was developed and applied to a universe of 200 stakeholders (directors, audit coordinators, team leaders, superintendents), of which we collected 72 responses, corresponding to a sample with the results with 95% confidence level and 9% of error margin. The results pointed out that more than 55% of respondents indicated that the

main objectives of the SFC Operational Plan are: organize the projects to be executed according to the priorities defined by the board of directors; firm commitment with the results to be delivered in the period; and, make possible the achievement of the strategic objectives of the CGU. When we analysed the responses separately, from the perspectives of each clustered groups of stakeholders – directors, superintendents, audit coordinators and audit team heads –, we found out differences in their perspectives. While the directors and audit team heads followed the priorities listed in the respondents' overview, the audit coordinators considered that the focus of the Operational Plan lies in the execution of the project and public policy delivery, diverging from the superintendents, who focus the Operational Plan on the achievement of CGU strategic objectives, according to the allocation of available resources. Thus, based on this information, we identified two groups of stakeholders with different and sometimes conflicting perceptions and preferences, which places the need for negotiation to find compromising solutions. In this sense, it was noticed the absence of instruments that could support these stakeholders to compose their portfolios of projects supported by an informed negotiation.

Reflecting upon the situation that is similar to other contexts, if we have an organization whose stakeholders need to make portfolio decisions, evaluating projects on a common basis, and if we have an opportunity to identify different perceptions from these groups of stakeholders, our proposed methodology can be useful and applicable. Notwithstanding, to do so, it is necessary to make use of participatory techniques to understand these perceptions, which can be made through interviews, web questionnaires, brainstorm, Delphi processes or other types of group sessions. And it is also necessary to understand where the divergences lie, which will be addressed and mitigated during the negotiation stages, since we are in a negotiating context.

This is the case of the CGU, which needs to define a common and transparent basis for choosing audit projects that means a baseline to evaluate audit projects independent of who is doing the evaluation. Once we are faced with groups of stakeholders with divergent and/or conflicting views, models must be built for each of these groups. There being many divergences in the views, as well as difficulties in joining all the stakeholders in the same table to build a common model, and conflicting interests, there will consequently be the need for negotiation. In the light of the foregoing, in our case study, we find that the audit coordinators differ in the opinion of the superintendents. Thus, it is appropriate to build two group models, one for audit coordinators and one for superintendents. From this point on, any audit coordinator representative can use his / her respective group template to evaluate the projects that he or she wishes to execute. The same goes for superintendent

representative. These representatives will need to negotiate to overcome divergences and reach a compromise set of audit projects that will be performed by their teams. This negotiation is no longer at the group level but in peers shape.

Detailing, Figure 4.1 summarizes key aspects from the proposal project selection process to define the audit projects to compose the SFC Operational Plan in our case study example. The structure of the SFC/CGU is divided into the audit coordinates, located in the central office, responsible for each topic of interest (social, economic, health, education, etc.) and regional offices located in each Brazilian federation unit, responsible for executing the audit projects in these multiple themes. Thus, as we will explain better in Section 4.4, we propose building value models for these two groups of stakeholders, one for the Audit Coordinations (AC) and another for the Superintendent - Head of Regional Offices (HR), better known as Superintendents, and that from now on we will call only Superintendents. They are responsible to define the projects of their teams. Individually, each representative of these groups must evaluate their projects to enter the Operational Plan. From the results, raise the differences and space for negotiation, in search of a compromise in the portfolio generated. For instance, if we take Regional I, it can execute projects from the economic and social areas and other areas. The Superintendent considers a set of projects to compose the portfolio that does not coincide with the opinion of the Audit Coordinators in these subjects' areas (economic and social). Therefore, they will need to negotiate to reach the compromise solution. And we can follow this logic for all pairs (Audit Coordinators x Superintendents) to complete the definition of the Operational Plan for all involved. We would thus have general models for clustered groups, based on a common and transparent basis, first with the models created for each group, and at the same time, opportunity to include the knowledge of each stakeholder, expert in the field, in the final decision of the selection of projects.

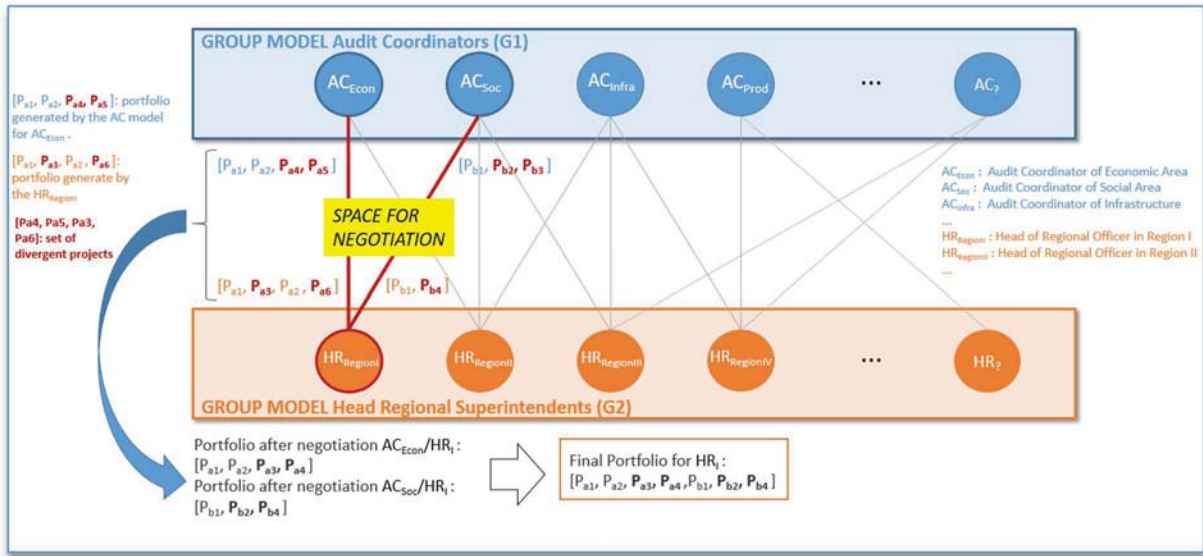


Figure 4.1 – Audit project selection process to SFC Operational Plan.

4.4. Proposed Socio-Technical Approach

Coping with what was explained, Figure 4.2 provides an integrated overview of the socio-technical approach designed and applied in this study, whose socio-technical stages are briefly described in the next subsections. The methodological proposal begins with the multicriteria portfolio modelling, making use of the multicriteria approach to structuring the value models to evaluate the projects by each group. The next step corresponds to the analysis of the outputs area by the results of value models through the evaluation of audit projects in terms of benefits and doability (Bana e Costa, 2001; Bana e Costa et al., 2001). Using different instruments/views, we can support situational analysis by different groups. With the identification of divergences (implications), it is time to define of negotiation strategies, in the sense of pursuing a compromise solution. Therefore, the methodological proposal is designed to deal with the situations of groups of stakeholders, whose perceptions can be modelled on a common basis and, at the same time, between these groups, we can be able to identify situations of divergence which can be the starting point for negotiation.

Our proposed approach differs from previous studies consolidated in the literature review section as it seeks to use multicriteria value modelling to support, as instruments, the negotiation stage. Moreover, since the methodology was built with the participation of the CGU stakeholders (from a real context), we have as a contribution the narrowing of the gap between the academic scientific

world and the real world. In addition, although the proposal has been validated within the audit context, we believe that it can be extended and/or adapted to other contexts.

In the next subsections, we present the steps to implement the proposed methodology. The first step is related to capturing and structuring the different perceptions within each stakeholder group, through the use of multicriteria portfolio modelling techniques. In subsection 4.4.2 we have brought the analysis of the outputs of models built in the previous step which represent the information gathered for negotiation. In subsection 4.4.3 we presented the informed negotiation framework proposal. And, in the subsection 4.4.4 we show how the whole process can support reaching a compromise solution.

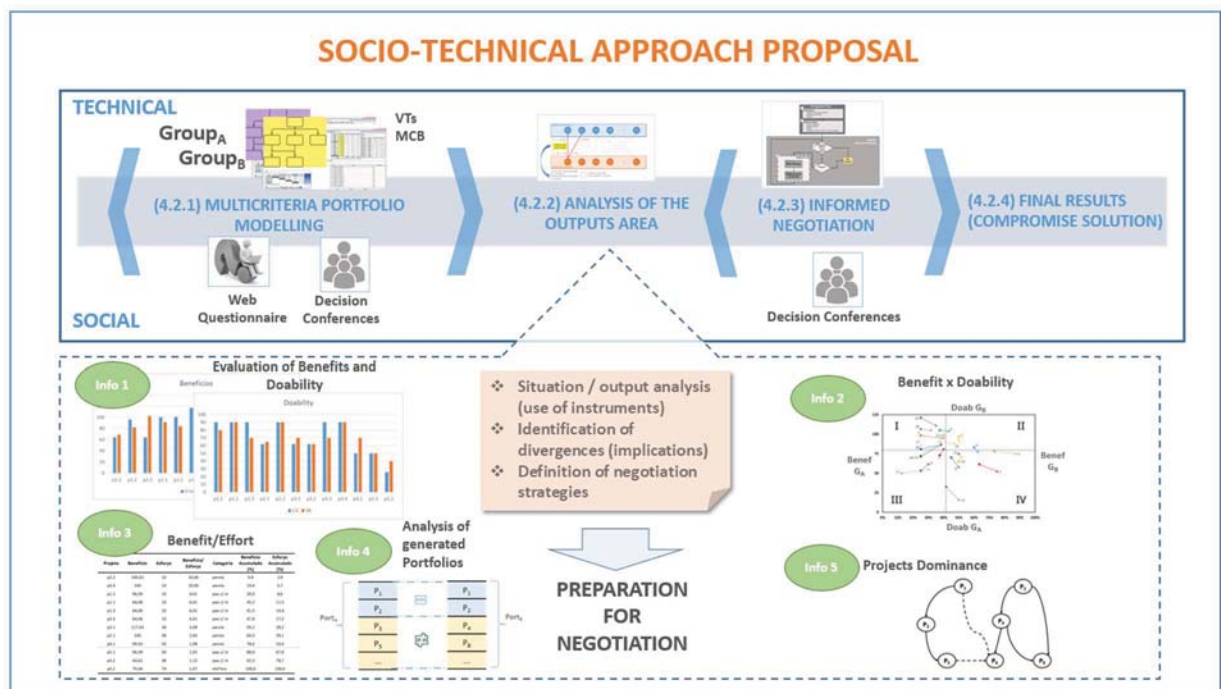


Figure 4.2 – Socio-technical approach to support the negotiation of audit projects.

4.4.1. Multicriteria Portfolio Modelling

On the social view of the process, in order to capture the preferences of the stakeholders groups involved in the decision context, we suggest make use of semi-structured interviews or web questionnaires (Bowling, 2009). Decision conferences, that involves a meeting with key players (stakeholders and experts) and an impartial facilitator, who is a specialist in decision analysis and works

as a consultant to assist the group, typically with the support of MCDA tools over a period of two full days to develop on the spot a common model through an interactive and iterative group process (Phillips and Bana e Costa, 2007), are also deemed as useful to structuring and validate the value models.

As shown in Figure 4.2 , on the technical view in this process, we consider appropriate the use of Portfolio Decision Analysis (PDA) techniques (Salo et al., 2011), which focus on portfolio choice (as opposed to the choice of a single alternative from a set) by appraisal of options across many issues and finding the best combinations of options for a given level of resource. (Phillips and Bana e Costa, 2007).

Beginning with structuring, value trees can be used to structure the fundamental dimensions/objectives of the problem and the criteria to assess potential benefits and risks of audit projects, according to the vision of each group of stakeholders (Bana e Costa, 2001; Bana e Costa et al., 2004). At this point, we propose using the MACBETH approach (Bana e Costa et al., 2012), supported by the DSS M-MACBETH, for building of the multicriteria value models to evaluate the audit projects since only requires qualitative judgments about differences of attractiveness to build the multicriteria value models, covering seven semantic categories of differences of attractiveness as follows: indifferent (I), very weak (VW), weak (W), moderate (M), strong (S), very strong (VS), extreme (E) (Fasolo and Bana e Costa, 2014). It is also necessary to clarify the descriptors of performance of each criteria, which can be considered as *"(...) an ordered set of (quantitative or qualitative) plausible impact level. Depending on the context, an evaluation criterion can be operationalized by a natural, proxy or indirect, or a constructed descriptor. If it is possible to define natural descriptors, this is the appropriate choice, since the more objective the descriptors are, the less ambiguous the criteria will be and, the less controversial the evaluation model."*(Bana e Costa et al., 2002, p.230)

Adapting the model reported in Oliveira et al. (2012), each stakeholder group must evaluate each audit project j to be included in the Operational Plan, according to the group model. The performance x_{ij} of each audit project j on each benefit criterion i can be measured by a level in the respective descriptor with partial value $v_i(x_{ij})$, constructed with MACBETH, in which we have $v_i(neutral_i) = 0$ and $v_i(good_i) = 100$. Within the audit context, the *neutral* level represents those projects whose impact or benefit value in executing the audit project does not change the *status quo* of the criterion, meaning that it does not impact in the associated public policy, which is within the scope of the audit project. The *good* level represents the value of impact or benefit considered satisfactory on criterion, in terms of impact of the control action (audit project) in the associated public policy. The differences between the attractiveness comparison of $good_i$ and $neutral_i$ in each criterion

allow to assign the weight k_i to each criterion i . Under an additive structure, which requires the respect for mutual independence conditions to be ensured in the structuring of the model, the value of the overall benefit v_j of the project j , can be determined as:

$$v_j(x_{1j}, \dots, x_{nj}) = \sum_{i=1}^n k_i \cdot v_i(x_{ij}) \quad (4.1)$$

$$\sum_{i=1}^n k_i = 1 \text{ and } k_i > 0 \text{ (} i = 1, \dots, n \text{)}$$

Considering Equation (4.1) in which each audit project j has $v_j > 0$ and cost c_j , B is the total of available resources, and as $l_j = 1$, if the audit project j is included in the best portfolio and *zero* otherwise, we have that the best project portfolio will be found by solving this optimization problem (additional constraints can be considered):

$$\text{maximize: } \sum_{j=1}^m v_j l_j \quad (4.2)$$

$$\text{subject to: } \sum_{j=1}^m c_j l_j \leq B, \quad (4.3)$$

$$l_j \in \{0,1\}, \quad j = 1, \dots, m.$$

Alternatively, still on multicriteria portfolio modelling context, the portfolio can be analysed through the lense of the prioritization approach. As presented by Lourenço et al. (2012), given a fixed budget B , the prioritization approach selects the portfolio formed by the projects j , $j = 1, \dots, k$ with $k \leq m$ (m projects that are worth funding), such that $\sum_{j=1}^k c_j \leq B$, and $\sum_{j=1}^{k+1} c_j > B$. In this approach, following Bana e Costa et al. (2006), one should follow these steps: use a multicriteria value model to determine the added expected benefit v_j , as Equation (4.1), for instance; define the cost c_j of each project; calculate the benefit-to-cost ratio ($r_j = v_j/c_j$) of each project; and, rank the projects from the

highest to the lowest benefit-to-cost ratio. Hence, in the prioritization approach the notion of “value-for-money” of a project is associated with the slope of each project's benefit-to-cost triangle, as shown in Figure 4.3, for illustrative purposes, in which the value-for-money of each project is given by the slope of its benefit-to-cost triangle (Lourenço et al., 2012).

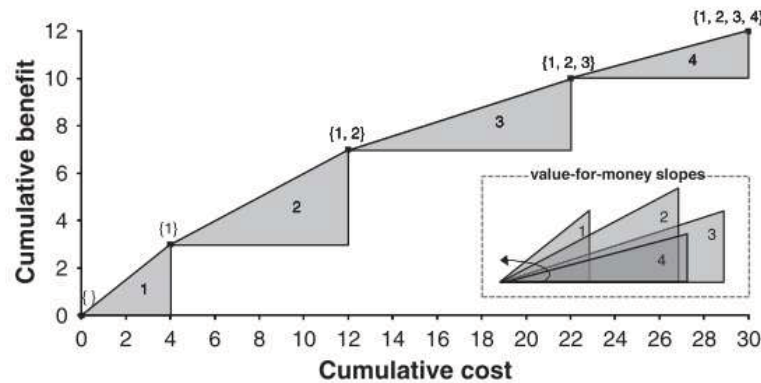


Figure 4.3 – Cumulative cost versus cumulative benefit chart showing the portfolios formed by benefit-to-cost ratio approach (source: Lourenço et al., 2012).

Thus, following Figure 4.2 , in the multicriteria portfolio modelling stage, as an input to the next step of the process (analysis of the outputs area), we suggest building value models for each stakeholder group, according to the different views and generated the portfolios using one of these approaches. Additionally, in case the costs are not well defined, the doability dimension, as proxy for audit cost, can also represent the extent to which each project can effectively be implemented, considering the limited resources and financial, legal, social, and other constraints that are beyond CGU managers’ control (Mateus et al., 2017). It is also important to survey, within this context, the issues of veto concepts (minimum requirements for included projects), which should be defined by CGU senior management and should be considered when defining the projects that will be evaluated by the models. The analysis of the divergences will be pointed out from the results of the evaluations of the audit projects in terms of benefits and doability according to each model, as detailed in the next subsection.

4.4.2. Analysis of the Outputs Area (Information Gathering for Negotiation)

From here, we suggest making use of the models validated by each group, which will be used to evaluate the audit projects for all the members of each group. As shown in Figure 4.1, after the definition of the group models, each representative of each group may need to interact with the representative of the other group, always in a peer relationship. Without loss of generality, if we take two representatives from each group, one can use these models to evaluate their projects and to obtain their portfolios of audit projects. Thus, from the value models defined for each stakeholder group, we are able to perceive the preferences of each stakeholder and get their portfolio generated, according to those interests. Subsequently, it is time to analyse the results that give rise to diverging situations and to begin to negotiate these divergences to try to reach a compromise solution. And one can analyse the results obtained through different instruments. As instruments/views, we can cite:

▪ **Info 1: Evaluation of Benefits and Doability, separately:** analysis/view of the benefits and doability of each audit project according to a group or groups of stakeholders (Bana e Costa et al., 2014). The results of the models generated for each group of stakeholders, in terms of benefit or doability in the execution of each audit project, can be exposed in a graphical way (Figure 4.4) that facilitates the perception of the audit projects in which greater returns are expected and those in which the doability can have more impact on the consumption of available resources. This may be useful for stakeholders at the time of negotiation in order to clarify the gain / loss impacts of abdicating some audit project during the negotiation.

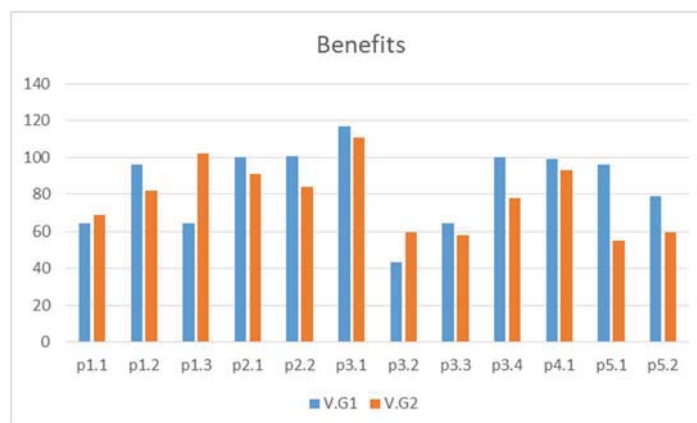


Figure 4.4 – Illustrative example of benefit assessment for a set of competing audit projects from the perspective of two stakeholder from different groups (illustrative groups G1 and G2, presenting the benefit assessment results, V.G1 and V.G2, for projects p1.1, p1.2, ..., p.5.2).

▪ **Info 2: Benefit x Doability Graph:** trading benefit off against doability should drive the selection of the best actions (Mateus et al., 2017). This graph allows stakeholders to perceive the expected impact and cost of each audit project, in the view of each party involved in the negotiation. We also suggested make use of Strategic Matrix (Figure 4.5), with 4 distinct quadrants, include the ‘pearls’ in the portfolio, and negotiate the ‘oyster’ and ‘bread and butter’ (Bana e Costa et al., 2014).

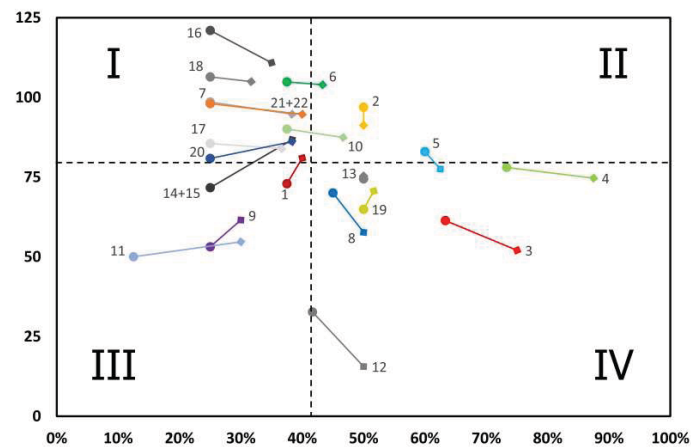


Figure 4.5 – Illustrative example of Strategic Matrix, with benefits of the projects on the Y-axis against their doability on the X-axis (source: Mateus et al., 2017).

▪ **Info 3: Benefit/Effort ratio:** prioritise the audit projects by their value-for-effort, defined as the ratio between the benefit and the effort scores, in line with the reasoning of a prioritization approach (Bana e Costa et al., 2014). This information is useful to rank the list of audit projects, allowing to perceive, in the view of each party, the order of projects with the best benefit/effort ratio (Figure 4.6).

Ranking					
Benefit	Options	Doability	Options	Ratio Benefit/Effort	Options
112,5	p2.1	90	p1.1	11,25	p2.1
112,5	p2.2	90	p2.1	6,00	p1.1
112,5	p2.3	90	p3.1	6,00	p3.1
112,5	p2.4	90	p4.1	2,75	p4.1
72,5	p1.2	50	p1.3	2,25	p2.2
60	p1.1	50	p1.4	2,25	p2.3
60	p3.1	50	p2.2	1,96	p2.4
55	p5.1	50	p2.3	1,17	p1.2
27,5	p1.3	42,5	p2.4	0,89	p5.1
27,5	p4.1	38	p1.2	0,55	p1.3
25	p1.4	38	p5.1	0,50	p1.4

Figure 4.6 – Illustrative example of ranking a set of audit projects by benefit/effort ratio.

▪ **Info 4: Portfolios according to the views of each group:** from the definition of the available budget, it is possible to define which audit projects will compose the portfolios according to the models of each stakeholders group, which means different portfolios of projects may be obtained. For instance (Figure 4.7), analysis of the differences and implications according to each auditing stakeholder will allow the identification of divergences should focus in preparation for discussion and negotiation between the stakeholders.

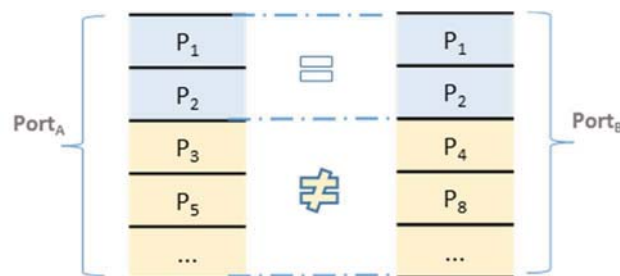


Figure 4.7 – Illustrative example of portfolios generated according to the views of each group, highlighting the differences.

▪ **Info 5: Dominance:** dominance analysis can be useful in negotiation as the dominance criterion is a natural starting point in selecting proposals (Sarabando et al., 2013). When seeking for agreement solutions, the examination of core index values makes it possible to analyse the non-dominated portfolios and provide relevant inputs for group deliberations about viable candidates (Salo, 1995; Vilkkumaa et al., 2014b). In this sense, it is worth analysing the audit projects within the portfolios and seeking to identify those who are always better than the other, showing that there is dominance, as

shown in the illustrative example in Figure 4.8. Some audit projects are strictly (Pareto) dominated by others in both benefits and doability dimensions and should therefore be selected only after the dominant ones have been selected. The dominance of an audit project over another is represented by a solid arrow indicating that the tail project dominates the head project.

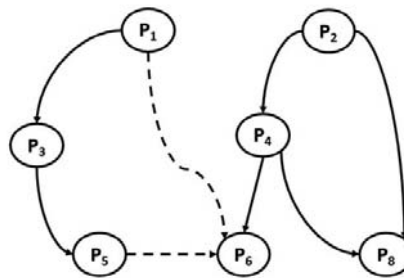


Figure 4.8 – Illustrative example of dominance graph.

4.4.3. Informed Negotiation Process

Once again, the participatory component of this stage must be supported by decision conferences, in which the author comments that it allows *“achieving better decisions to creating shared understanding amongst key players, developing a sense of common purpose, and gaining commitment to the way forward”* (Phillips, 2005). In order to create a suitable environment for discussion, a mediator or facilitator should be defined, ideally an impartial, highly ethical, knowledgeable intermediaries, with skills to conduct the negotiation session and to help the stakeholders to negotiate constructively, perhaps by suggesting compromises solutions (Raiffa, 1982). And from this point on, CGU stakeholders who will interact in the negotiation process will assume the role of negotiators (Greenhalgh and Chapman, 1998) who do more than just make offers: they will try to influence their counterparts’ perceptions of the problem and the offers they are making (Vetschera, 2013). It is also important to highlight the role of arbitration, under which, a neutral third-party with authority renders a decision after hearing the arguments from each party and the two parties commit to conform to his recommendation (Goltsman et al., 2009).

As emphasized by (Górecka et al., 2016, p.1102), a pre-negotiation phase should be defined to establish a detailed *“vision of the negotiation problem, the parties involved and the context and, after analysing them, define a negotiation strategy that would allow the party to obtain the goals”*. Thus, we propose that the initial negotiation template is focused on the issues that have generated

disagreements among stakeholders, i.e., from the set of audit projects that showed greater differences in value when applied the built models. The actual negotiation started by an initial stage, in which two offers were submitted at the negotiation table, one by each of the parties. At each negotiation stage it shows the negotiator the scale of differences that need to be eliminated to achieve a compromise between the parties and what their endeavours in achieving the current negotiation status. It also allows identifying the moments of reverse concessions and, by analysing the structure of the offer sent, focusing on the most competing issues.

It is also important to bear in mind the desirability to reach the best alternative to a negotiated agreement (BATNA) earlier described. As an illustrative example, applying Keeney's concept (1992), suppose we have a negotiation situation between two stakeholders in CGU, an audit coordinator (AC) and a superintendent (HR). Suppose that value functions V_{AC} and V_{HR} are assessed for the audit coordinator and the superintendent respectively, scaled each from 0 to 100 and the expected utility of a portfolio A to the audit coordinator and to the superintendent can be denoted as $V_{AC}(A)$ and $V_{HR}(A)$. Finally, suppose that the BATNA values for each party have been calculated as $V_{AC}(\text{BATNA}) = 20$ and $V_{HR}(\text{BATNA}) = 30$. As shown in Figure 4.9, there are presumably portfolios such as D, E, F, and G that would be preferable to both relative to their respective BATNAs. The tactic is to find them.

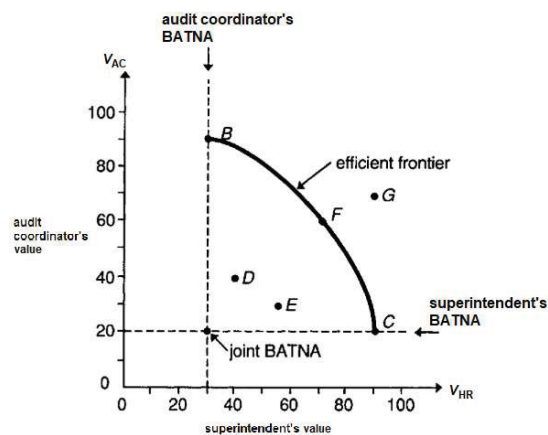


Figure 4.9 – A negotiation situation involving two stakeholders – adapted from Keeney (1992).

And finally, we bring in the concept of logrolling, in which loss in some issues is negotiated for gain in others, resulting in overall gain for all parties, based on the integrative negotiation strategy. *“It is the exchange of loss in one issue, usually less important in priority, for gain in the other issue, usually more important. The difference in preference between the two issues results in an increase of the*

overall value for both parties, that is, mutual gain. Even if the parties prefer the same issue, as long as there is a difference in how much they prefer, logrolling can still apply”. (Tajima and Fraser, 2001, p.220)

With these concepts in mind, herein we present the scheme of the negotiation process, as shown in Figure 4.10, followed by a pseudo-algorithm to implement it (Figure 4.11), described in detail in the box below. First, there is a pre-negotiation phase, which raises the initial settings for negotiation as the negotiation checklist. The following phase is how to give the rounds of the integrative negotiation/bargaining steps and the stop conditions.

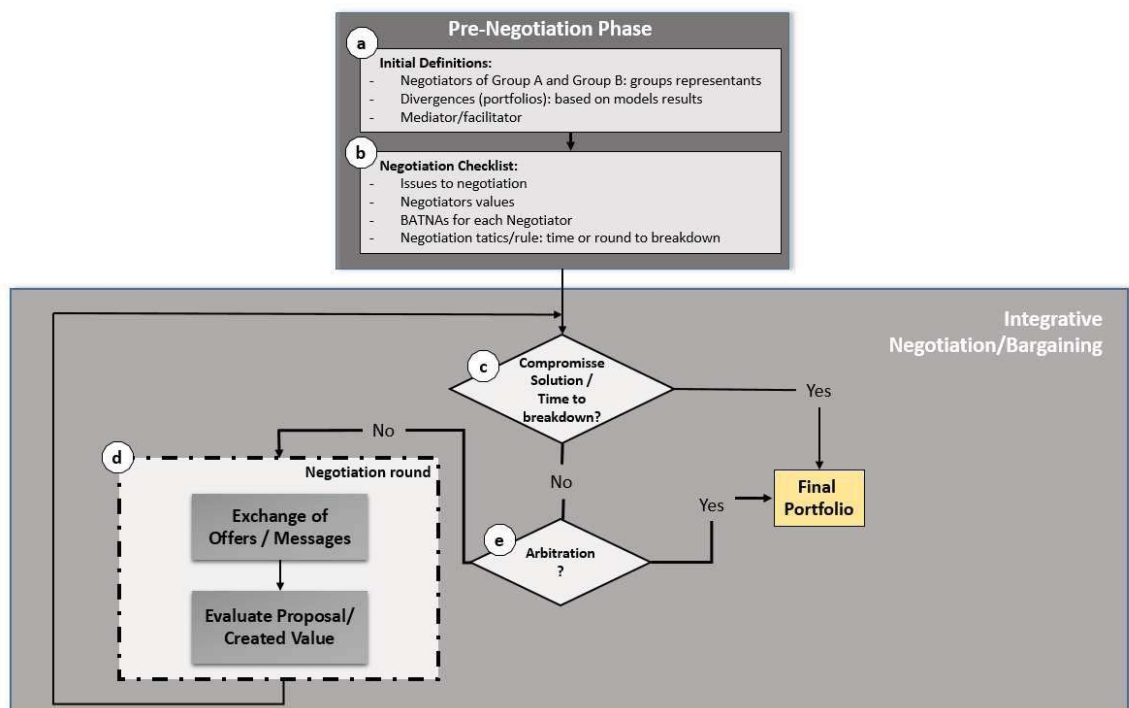


Figure 4.10 – Negotiation scheme.

Algorithm 1: Informed Negotiation Process

Input: *Negotiator N1, Negotiator N2, $S_t^\#$, S_t^- , S_t^+ , $t_{breakdown}$*

Output: P // Portfolio of audit projects after negotiation

/ Initial definitions */*

```
1  $S_{BATNA}^1 = \{\text{subset defined as BATNA for N1}\};$ 
2  $S_{BATNA}^2 = \{\text{subset defined as BATNA for N2}\};$ 
3 .
4 while ( $S_t^\# \neq \{\}$   $\vee t \neq t_{breakdown}$ ) do
5   if ( $t==1$ ) then // First round
6      $S_1^+ \leftarrow \{\text{Subset of projects that both negotiators agreed}\};$ 
7      $S_1^- \leftarrow \{\text{Subset of projects that negotiators disagreed}\};$ 
8   else // Negotiation round
9     N1 and N2 exchanges offers/messages about projects based on  $S_t^\#$  and
        $S_1^-$  elements;
10    N1 and N2 evaluate proposal/created value;
11     $S_t^\# \leftarrow S_t^\# - \{\text{Negotiated projects agreed to include in } P\};$ 
12     $S_t^- \leftarrow S_t^- + \{\text{Negotiated projects agreed to exclude of } P\} - \{\text{Negotiated}$ 
        $\text{projects agreed to include in } P\};$ 
13     $S_t^+ \leftarrow S_t^+ + \{\text{Negotiated projects agreed to include in } P\};$ 
14     $t++$ ;
15 if ( $S_t^\# \neq \{\}$ ) then// Need for an arbitrator decision
16   Based on  $S_t^\#$  and  $S_t^-$  the arbitrator decides the  $S_t^+$ ;
17  $P \leftarrow S_t^+$ ;
18 return  $P$ ;
19
```

Figure 4.11 – Informed Negotiation Process Algorithm.

Pre-negotiation Phase: strategic and analytical preparation work**(a) Negotiation Checklist:**

- Negotiators (groups' representative): define the parties involved in the negotiation, N1 and N2, which will represent the members of each group in the negotiation to define portfolios of audit projects;
- Divergences (portfolios): identification of divergences, in an attempt to cluster the audit projects according to the results of the evaluation models, for discussion and negotiation between parties;
- Define the mediator: aim to encourage cooperation, information sharing and joint resolution of problems. Can also make the role of facilitator and who will be the interlocutor in the negotiation.

(b) Initial Definitions:

- Issues to negotiation: Considering S_t^- the subset of projects with the greatest divergence of values and not yet included in the portfolio at round t , S_t^+ is the subset with agreement between the parties to compose the portfolio at round t , and $S_t^\#$ the subset with the projects for negotiation;

- Define the best alternative to a negotiated agreement (BATNA) for both: defines their bargaining strength and may be used as a reference point; (line 1 and 2)

- Identify the initial offers/proposal of negotiators: defined the sets of audit projects they would like to perform, as well as the veto concepts (minimal requirements for included projects).

- Define negotiation tactics/rules: define time or round to breakdown.

Integrative Negotiation/Bargaining procedures:

(c) Check if compromise solution was reached or time to breakdown is over: (line 4)

- Final portfolio (compromise solution) or no agreement;

- Continue to next step.

(d) Negotiation Round: (lines 5 – 14)

- Initial Negotiation Template: portfolios with the divergences; knowledge of the available multicriteria instruments/views;

- Search for win-win solution: generate the portfolios containing the possible combinations with these projects, measuring the aggregate values of each option (integrative negotiation);

- Negotiation rounds: next, negotiators would choose, one by one, the projects that would be the least value to them to be excluded from the portfolio (concessions and trade-offs), until the compromise solution was generated (bargaining procedures). They can make use of logrolling, *“that is the exchange of loss in some issues, usually less important in priority or value, for gain in other issues, usually more important”* (Tajima and Fraser, 2001);

- Audit projects that will be included in the portfolio are added to subset S_t^+ and taken from subset $S_t^\#$. In the end, the projects that will not make up the portfolio are in subset S_t^- . Remembering that although the projects in S_t^- are considered the most difficult to negotiate, nothing prevents some of them are negotiated and compose the final portfolio.

(e) If there is no agreement: (lines 15 and 16)

- Presence of arbitration: someone with superior decision-making authority (Aghion and Tirole, 1997) makes the decision based on the information shown (Goltsman et al., 2009).

4.4.4. Final Results (Compromise Solution)

The methodological suggestion supports resource allocation decisions as choice and definition of the portfolio within a negotiation perspective. At the end of offers and communications exchanges, it is expected that a compromise solution will be reached and a final portfolio agreed. Thus, grounded on the information gathered in the analyses that arise in the structuring of the multicriteria models to portfolio analysis, the negotiators can be able to reach a compromise solution based on an informed negotiation framework.

4.5. CASE STUDY: SFC Operational Plan

The case study presented in this study is centred on the elaboration process of the SFC Operational Plan, which materializes the audit projects to be performed during the next year by CGU teams. The SFC audit units' structure is divided by thematic areas of public policies (education, health, infrastructure, etc.), within its audit coordinations (for instance, the Audit Coordinator of Transport Theme within Infrastructure Area). The set of possible lines of action for audit projects is already pre-established and range from the Annual Audit of Accounts, Evaluation of the Government Programs Execution, Management Results Evaluation, Audit in Contracts with External Resources, Analysis of Personnel Acts, Verification of Complaints and Social Demands, and so on. Thus, some examples of audit projects carried out by the Audit Coordination of Transport teams would be: Evaluation of the Government Programs Execution to duplication of road BR-381, Management Results Evaluation of Urban Transportation System.

The SFC Operational Plan is developed in articulation with the directors, audit coordinators and superintendents. It has been reported that previously at CGU the audit coordinators have had difficulties in reaching an agreement with the superintendents when there are divergences. Previous studies carried out within this thesis have confirmed this perception and have identified those two groups of stakeholders (the audit coordinators and the superintendents) with different objectives and value systems, having diverging views concerning the work to be accomplished by audit teams and in terms of what should be considered to select audit projects to compose the SFC Operational Plan. The views of directors were found to be similar to those of the audit coordinators group. Details of this report are described in Chapter 3. Therefore, in this study we consider that the directors are

represented by the audit coordinators and we focussed only on the peer relationship between the latter and superintendents.

In order to facilitate understanding, in spite of the fact that the applied socio-technical process has occurred simultaneously in terms of social and technical steps, we will present below how the participatory process followed and then describe the process and final results entailed in the technical process.

4.5.1. Timeline of the adopted Social Process

Summarizing the whole participatory process carried out at CGU (including the work already reported in the previous Chapters), Figure 4.12 presents the timeline of the social process including the decision conferences, the interviews, the participatory structuring and negotiation sessions. It is important to realize that, except for the negotiation session where we have decisions taken by representatives, all other social process steps involve group decisions with a large number of stakeholders and decision-makers from CGU being involved.

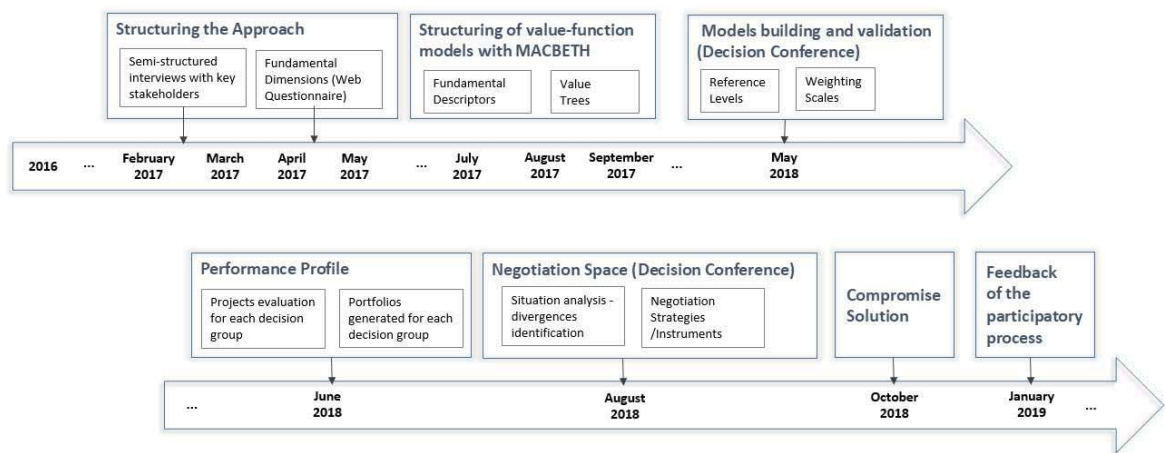


Figure 4.12 – Timeline of social process to the application of the methodology in the case study.

The step '*Structuring the Approach*' shown in the timeline was the first to be carried out and was implemented through stakeholder participation in the form of interviews and web questionnaires. The detailed description of how the elaboration and application of the semi-structured interviews and the web questionnaires were carried out was described in the Chapter 3 emphasizing the description of the technical perspective applied to the process. The same can be observed in the step '*Structuring of*

value-function models with MACBETH' in the sequence of the analysis of the results raised in the previous step, which led to the identification of fundamental concerns that were clustered into value trees for each stakeholder group.

Then, the participatory process began after the identification of the two group of relevant stakeholders that were representative and could come together to build and validate the group models built based on the information gathered in the previous phase. Given that, as explained earlier, it was deemed as relevant by CGU to address the situation involving two groups of stakeholders with differing views and efforts were done to identify some representatives of these two groups (audit coordinators and superintendents) who could support this research and contribute to this process. Therefore, the group of audit coordinators was composed of six coordinators and the group of superintendents was composed of five participants.

Then, separate decision conferences were planned for each stakeholder group, so that members discussed the information concerning only to their groups. After dealing with availability issues from participants, three half-day sessions were organized separately with each group, to accommodate their agendas. Sessions with superintendents were supported through videoconferences because participants of this group were geographically disperse within Brazil. In the end, we had the total of six half-day decision conference sessions with the two groups, which will be presented numbered below, to facilitate understanding. Sessions (1), (2) and (3) were conducted with the group of six audit coordinators and sessions (4), (5) and (6) refer to the sessions with the group of five superintendents. The results of these sessions are presented in the next section.

▪ **Decision Conference Session (1) with the audit coordinators**

During this decision conference session, the participants were invited to discuss the key concerns when they choose audit projects to compose the Operational Plan. In the first decision conference meeting, they have been introduced to some basic concepts of building an evaluation model with MACBETH and with a detailed description of the modelling tasks that should be undertaken to construct a multicriteria evaluation model. After two to three hours of discussion, a shared understanding was reached about the meaning and scope of each key dimension suggested to the group. Three key dimensions were defined for the audit coordinator group model. The dimensions 'alignment with tactical plan priorities', 'relevance' and 'impact/benefit of audit project' were validated by the group as the most representative when choosing an audit project. The value tree developed to audit coordinator group were approved by the group, as shown in Figure 4.13a. These dimensions will

be later taken as the criteria to evaluate the potential benefits of the audit projects. Furthermore, a doability dimension was included, representing the extent to which each audit project can actually be implemented, considering the limited resources and other constraints that are beyond the control of the stakeholders. That way, trading benefit off against doability should drive the selection of the best audit projects (Bana e Costa et al., 2014).

▪ Decision Conference Session (2) with the audit coordinators

The next session with group started by the review of descriptors of the set of evaluation criteria and weighting of the each level of impact of each criterion established in the value tree. The group discussed the descriptors of impact on each evaluation criterion defined for the model, in order to make the scales coherent and understandable. Some adjustments were considered. Then, the group chose for each pair defined in the MACBETH judgment matrix for each criterion one qualitative value judgment from the MACBETH scale. Constructive discussions emerged at the time that the group was seeking an agreement in judgments and thereby group judgments entailed in some cases more than one MACBETH qualitative judgment, e.g. 'moderate-strong', which is permitted by MACBETH approach. The facilitator asked the group to identify relevant upper and lower references, with the *good* and *neutral* references being respectively selected.

▪ Decision Conference Session (3) with the audit coordinators

In the last session the facilitator used a questioning protocol for the group provide weighting judgments to weight the benefit criteria. The specific preference elicitation procedure consisted of a set questions presented sequentially, as follows:

1. At first, the audit coordinator group was confronted with a decision to choose the most important from a set distinct swings, one for each benefit criterion (*'Alignment with Tactical Plan priorities'*, *'Relevance'* and *'Impact / Benefit of audit project'*) on its model, and each one corresponding to an improvement in an audit project from the lower reference (neutral) to the impact level defined as upper reference (good) on the related criterion;
2. The next question concerned the overall evaluation about the difference of attractiveness of the selected swing, i.e. between the lower reference and the contribution of the previous selected action, drawing the answer from the MACBETH semantic scale;
3. The next question was similar to the first one, but considering only the remaining swings;

4. Henceforth, the questioning protocol automatically followed a succession of similar questions until there were no further swings to be evaluated.

After this step, the final model was approved by the audit coordinators group and they considered that the constructed model correctly represents their preferences when defining an audit project to compose their operational plans.

As feedback, we recorded the participants' reports, who realized the relevance and applicability of the study project to CGU (need for a common model and inputs to negotiate with the superintendents).

▪ **Decision Conference Session (4) with the superintendents**

A videoconference with the superintendents group was held to discuss the key concerns that they considered when they choose audit projects to compose the Operational Plan. Similar to the first session conducted with audit coordinator group, the participants also were introduced to some basic concepts of the MACBETH method and with a detailed description of the modelling tasks that should be undertaken to construct the MCDA evaluation model. After the half-day session, a shared understanding was reached about the meaning and scope of each key dimension suggested to the group. Three key dimensions were also defined for the superintendent model. The dimensions 'criticality', 'relevance' and 'alignment with tactical plan priorities' were considered key by the group. The value tree developed to superintendent group were approved by the group, as shown in Figure 4.13b. Also, these dimensions will be later taken as the criteria to evaluate the potential benefits of the audit projects. Furthermore, as in the audit coordinator group model, a doability dimension was included.

▪ **Decision Conference Sessions (5) and (6) with the superintendents**

Decision conference sessions (5) and (6) were conducted with the group of superintendents in a similar way as described in (2) and (3) sessions with the group of audit coordinators. Superintendents also reviewed the descriptors of performance, built value functions and weights to the benefit criteria, and modelled doability. After discussions and contributions, the final model was approved to evaluate the audit projects to be prepared for the Operational Plan.

Thereby, with the models constructed and validated, the next step was to evaluate the audit projects according to each criteria of the models. Out of the results, the differences emerged, which

will be the inputs to the negotiation stage. In these sessions the stakeholders were able to digest and think about what was being addressed during those intervals between the meetings.

After all, the model was constructed in group for each of these types of stakeholder but will be used by each audit unit individually. As a result, other coordinators and superintendents, who did not necessarily participate in the phase of models construction, can use these baselines to analyse and evaluate their audit projects. In this sense, an audit coordination and a superintendent were selected to suggest their sets of audit projects, to evaluate the projects according to the models, and to check the results.

4.5.2. Results from Multicriteria Portfolio Modelling (Group Modelling)

Reviewing, information gathered from the early stages of structuring the approach showed the main factors considered by each group of stakeholders when choosing an audit project.

For the audit coordinators, the selection criteria are:

- Institutional priorities defined by the Tactical Plan
- Operational Capacity
- Relevance (Government Strategy, Manager Priority, Media Placement, Demand from Defense agencies)
- Expected benefits of project execution

For the superintendents, the selection criteria are:

- Operational Capacity
- Criticity (Complaints, CGU Performance, Results from previous work, Demand from Defense agencies)
- Relevance (Government Strategy, Social/Economic Impact, Media Placement)
- Institutional priorities defined by the Tactical Plan

In this way, the two different models reflect the views of each group of stakeholders regarding the evaluation of benefits of the audit projects, as detailed in section 4.3. The value trees built for each group are shown in Figure 4.13. The criteria defined for evaluation of the audit projects, according to each group, are highlighted in red. A full description of the models can be found in the Chapter 3.

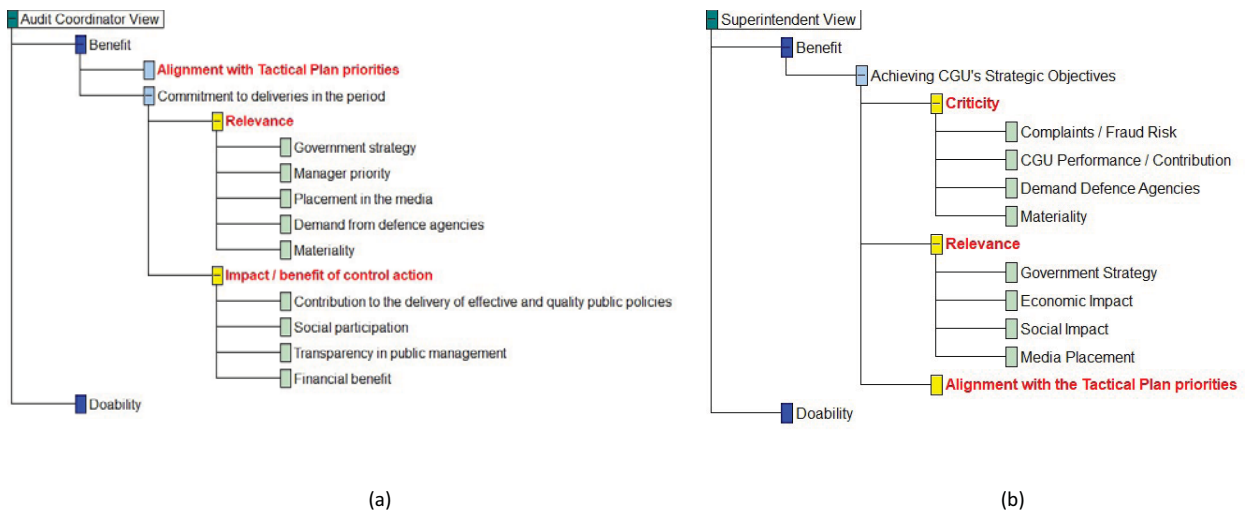


Figure 4.13 – Criteria set (in red) to evaluation of the audit projects, according each group.

The descriptor for the 'Relevance' criterion in audit coordinator view is given below for illustrative purposes. The descriptors of the remaining criteria are presented in Appendix III.

Table 4.2 - Descriptor for the 'Relevance' criterion in audit coordinator view. The impact level '+++' corresponds to upper reference (good) and the impact level '0' corresponds to lower reference (neutral) in the model.

Impact Level	Description: In terms of the relevance of the audit project, namely 'if it is a government strategy, if it is a priority for the manager, if it is placement in the media, if it is associated with demands from defence agencies or have expressive materiality', the implementation of the audit project...
+++	presents a link to all aspects considered relevant (government strategy, manager priority, media repercussion, defence agencies demand and materiality);
++	is linked to at least three aspects considered relevant and not at all (government strategy, manager priority, media repercussion, defence agencies demand and materiality);
+	is linked to one or two aspects that are considered relevant and not to all (government strategy, manager priority, media repercussion, defence agencies demand and materiality);
0	is not related to any of the aspects considered relevant.

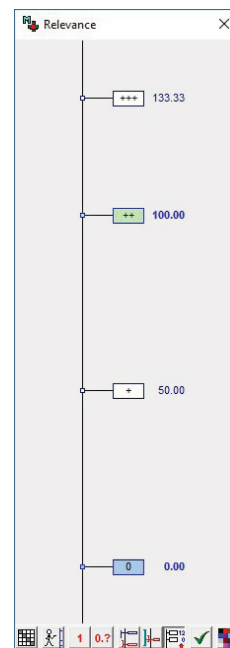
Next, it was necessary to build the value scales for the model generated by each stakeholders' groups. This procedure was supported using the MACBETH approach, in which each group of stakeholders discussed and defined the differences in attractiveness between each reference level of impact of each criterion, as well as the weighting scales among them. In this sense, *good* (set in green) and *neutral* (set in blue) impact references are also defined, which represent, respectively, that the

value of impact or benefit is considered satisfactory on criterion in terms of impact of the control action (audit project) in the associated public policy or that the impact or benefit value in executing the audit project does not change the *status quo* of the criterion – meaning that it does not impact in the associated public policy. An audit project whose impact on its execution does not bring any added value should be considered as *absolute zero* in the value model – meaning that it is not worth selecting it to compose the portfolio.

Following the questioning protocol described in the previous subsection, carried out during decision conferences, the stakeholder groups provided attractiveness judgments from a set of distinct swings, to weight the benefit criteria set and built the value functions. Figure 4.14 shows the weighting scales for the criterion ‘Relevance’, for illustrative purposes, and the weighting of the criteria in the model of the Audit Coordinators group. Figure 4.15 shows the weighting scale for the criterion ‘Criticality’, for illustrative purposes, and the weighting of the criteria set in the model of the Superintendents group.

Relevance					Current scale	
	+++	++	+	0		extreme
+++	no	weak	strong	extreme	133.33	v. strong
++		no	moderate	strong	100.00	strong
+			no	mod-strg	50.00	moderate
0				no	0.00	weak
						very weak
						no

Consistent judgements



Weighting (Audit Coordinator View)

	[PrioPT]	[Relevance]	[Impact]	[all lower]	Current scale
[PrioPT]	no	vweak-weak	moderate	extreme	40
[Relevance]		no	weak	extreme	35
[Impact]			no	extreme	25
[all lower]				no	0

Consistent judgements

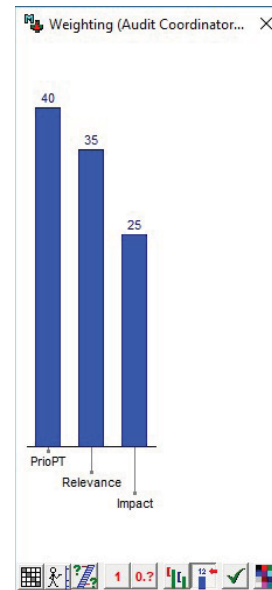
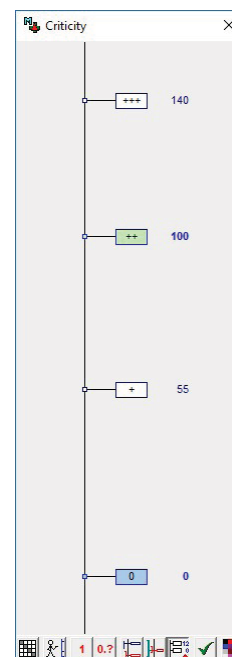


Figure 4.14 – Audit Coordinators group model: scoring for the ‘Relevance’ criterion, and weighing scale.

Criticality

	+++	++	+	0	Current scale
+++	no	moderate	strong	extreme	140
++		no	positive	positive	100
+			no	positive	55
0				no	0

Consistent judgements



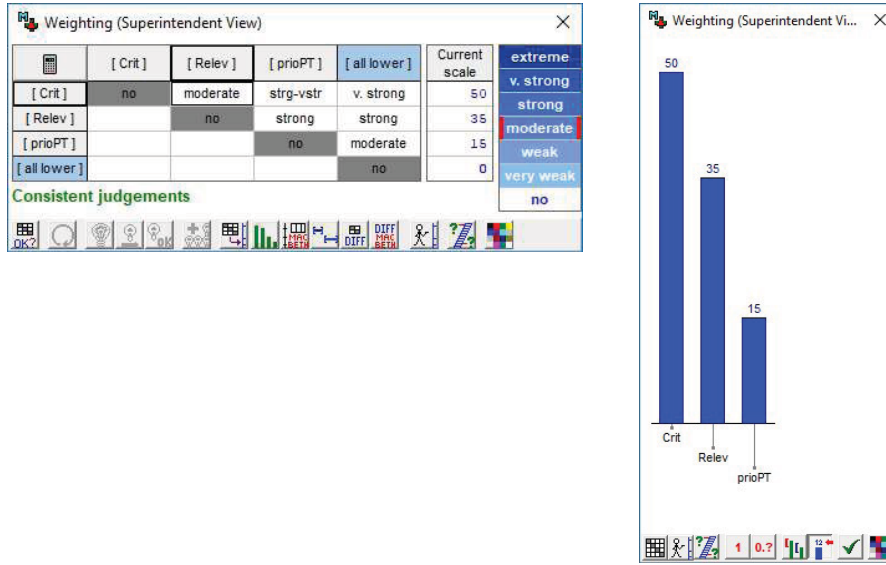


Figure 4.15 – Superintendent group model: scoring for the ‘Criticality’ criterion, and weighing scale.

With the criteria and weights defined, we were able to obtain the value functions for each group model. The benefits of the audit project are represented by their overall scores computed by adding the products of the partial value scores of the audit project on the benefit criterion by the respective weights. This simple linear-additive value function model assumes the existence of mutual preferential independence between the criteria, and thus the models were built to respect this property. As already explained in Equation (4.1), the performance x_{ij} of each audit project j on each benefit criterion ($i = 1, 2, 3$) for the both models can be measured by a level in the respective descriptor with partial value $v_i(x_{ij})$. The value of the overall benefit v_j and v'_j of the project j , for the audit coordination model and superintendent model, respectively, can be determined as shown in Equations (4.4) e (4.5) :

$$v_j(x_{1j}, x_{2j}, x_{3j}) = \sum_{i=1}^3 k_i \cdot v_i(x_{ij}), \text{ where } k_i = \{0,4 ; 0,35 ; 0,25\} \text{ (} i = 1, \dots, 3 \text{)} \quad (4.4)$$

$$v'_j(x'_{1j}, x'_{2j}, x'_{3j}) = \sum_{i=1}^3 k'_i \cdot v'_i(x'_{ij}), \text{ where } k'_i = \{0,5 ; 0,35 ; 0,15\} \text{ (} i = 1, \dots, 3 \text{)} \quad (4.5)$$

With the value functions defined it is time to generate project portfolios according to each model. At this point, it is possible to make use of the optimization or prioritization approaches. Under

cases of interdependences between projects, for instance when an audit project can only be performed concomitantly with another audit project, optimization is suggested, by solving Equations (2) and (3) with appropriate DSSs. But in our case, as we focus on the individual evaluation of each project and its feasibility of execution, the prioritization approach was selected. It is worth mentioning that we used the dimension 'doability', as a proxy for the cost of the audit project, in which the amount of man-hours, technical skills and logistical resources to execute the audit project were considered, as shown in Figure 4.16 and Figure 4.17, and as captured by a multicriteria evaluation model built with key perceptions of audit coordinators and superintendent groups in terms of doability. Thus, we defined the doability d_j of each project; calculate the benefit-to-effort ratio ($r_j = v_j / (100 - d_j)$) of each project, and, rank the projects from the highest to the lowest benefit-to-effort ratio. The results are shown in the next section.

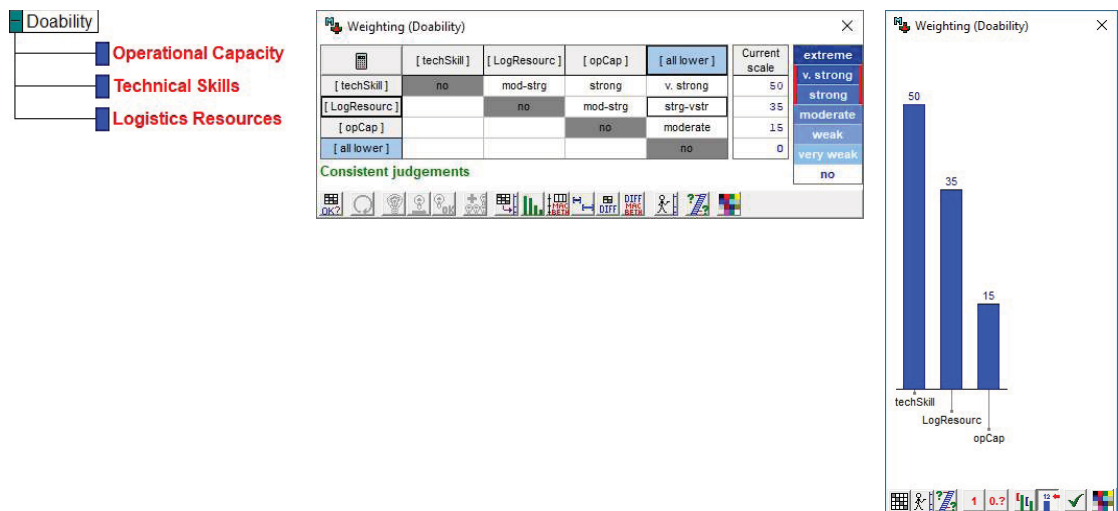


Figure 4.16 – Doability for audit coordinators group model structure, weighting judgments and weighing scale.

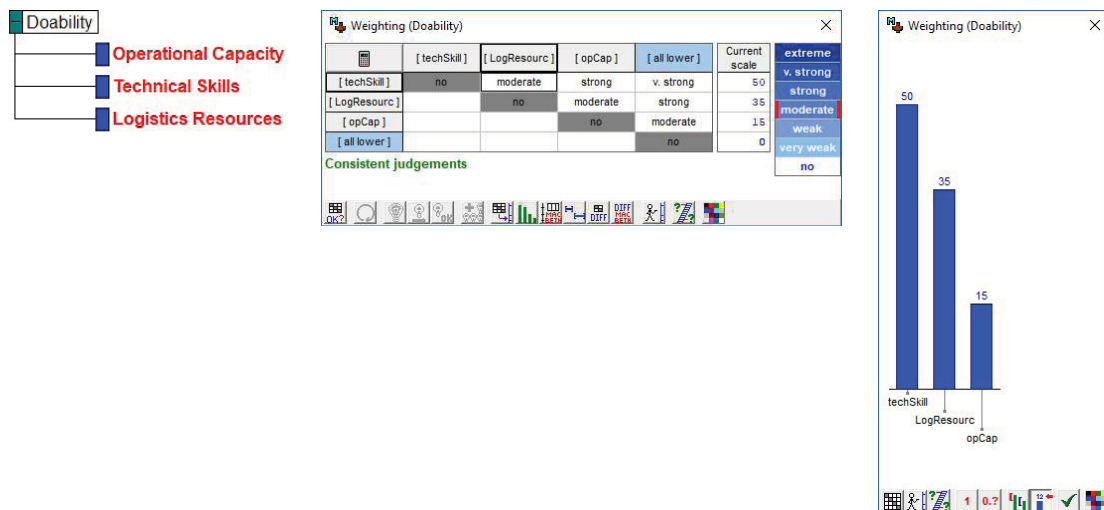


Figure 4.17 – Doability for superintendent group model structure, weighting judgments and weighing scale.

4.5.3. Audit Projects Evaluation Results (Analysis of the Outputs Area)

Recapping, as a result of the previous phase, we have models validated by the two groups (audit coordinators and superintendents) that will be used as a common base and applicable to any representatives of these groups, respectively. So now, individually, an audit coordinator and a superintendent were selected to suggest their sets of audit projects and to negotiate if the portfolios defined by their models differ. They then will define the sets of audit projects they would like to perform, as well as the veto concepts (minimal requirements for included projects).

As shown in Figure 4.1, we have cross-iteration of each thematic audit coordination with the others regional offices, and vice-versa. However, currently, this is not done supported by a structured negotiating framework. Thus, without loss of generality, to present the methodology and given the negotiations that will take place in pairs, we present the snippet of the sets of projects that are of interest to one audit coordinator and to one superintendent. The audit projects are listed by audit type (line of actions) and the names of the projects have been little modified for the purpose of preserving CGU's internal work information.

The audit coordinator suggests the projects listed in Table 4.3 to be part of its portfolio.

Table 4.3 – Set of audit projects selected by the audit coordinator.

Options	Name
p1.1	<i>Apuração - Ampliação do sistema de esgotamento sanitário - MG</i>
p1.2	<i>Apuração Denúncias - PMCMV</i>
p2.1	<i>Avaliação - Obras de distribuição de água e esgotamento sanitário</i>
p2.2	<i>Avaliação - Fiscalização no BPC</i>
p2.3	<i>Avaliação - ARG Fábrica de Software</i>
p2.4	<i>Avaliação - ARG Avançar Cidades</i>
p3.1	<i>Gestão Hídrica - Avaliação do Risco Hídrico - 1a Etapa exploratória</i>
p3.2	<i>Gestão Hídrica - CGMCID/DF</i>
p4.1	<i>Monitoramento PPP - STU/CBTU</i>
p5.1	<i>Mapeamento de Riscos Mcidades</i>

On the other hand, the superintendent suggested the projects listed in Table 4.4 to be performed by his team.

Table 4.4 – Set of audit projects selected by the superintendent.

Options	Name
p'1.1	<i>Apuração - Ampliação do sistema de esgotamento sanitário - MG</i>
p'1.2	<i>Apuração - Ginásio Poliesportivo - MG</i>
p'2.1	<i>Avaliação - Obras de distribuição de água e esgotamento sanitário</i>
p'2.2	<i>Avaliação - Fiscalização no BPC</i>
p'2.3	<i>Avaliação - Adequação de trecho rodoviário - duplicação da BR-XXXMG</i>
p'2.4	<i>Avaliação - ARG obra Campus Universitário - MG</i>
p'2.5	<i>Avaliação - ARG cronograma obra duplicação BR-YYY</i>
p'3.1	<i>Gestão Hídrica - Avaliação do Risco Hídrico - 1a Etapa exploratória</i>
p'4.1	<i>Monitoramento PPP - STU/CBTU</i>
p'5.1	<i>Atuação da Regulação - CFEM e TAH - 1a. Etapa</i>

One can observe that there are projects that are not mentioned by both representatives, that is, there are projects that are only endorsed by one of the parties, such as projects {p1.2; p'1.2; p2.3; p'2.3; p2.4; p'2.4; p'2.5; p3.2; p5.1; p'5.1}. These sets of projects should also be evaluated by the models of the other party, so that the perceptions of both sides are captured. This information is then used for negotiation.

Thus, following the methodology, we had the following performance matrices of the sets of projects presented in Table 4.5 and in Table 4.6. The projects with the "p'_" marking are the projects that were not in the audit coordinator list but that were evaluated by his model. The same was true for "p_" projects in the case of the superintendent's matrix. In this sense, at the end we had the same sets with 15 projects to be evaluated by the two models.

Table 4.5 – Partial and overall value scores for the audit coordinator suggested projects (supported by M-MACBETH).

Table of scores

Options	Overall	PrioPT	Relevância	Impacto
p 3.1	112.50	100.00	100.00	150.00
p 3.2	112.50	100.00	100.00	150.00
p' 2.3_	112.50	100.00	100.00	150.00
p' 2.5_	111.67	100.00	133.33	100.00
p 2.2	100.00	100.00	100.00	100.00
[all upper]	100.00	100.00	100.00	100.00
p' 2.4_	85.00	62.50	100.00	100.00
p 2.4	72.50	0.00	100.00	150.00
p' 5.1_	60.00	0.00	100.00	100.00
p 5.1	55.00	0.00	50.00	150.00
p 2.1	45.00	0.00	100.00	40.00
p 1.1	27.50	0.00	50.00	40.00
p 1.2	27.50	0.00	50.00	40.00
p 2.3	25.00	0.00	0.00	100.00
p 4.1	10.00	0.00	0.00	40.00
p' 1.2_	10.00	0.00	0.00	40.00
[all lower]	0.00	0.00	0.00	0.00
Weights :	0.4000	0.3500	0.2500	

Options

- +	Name	Short name	
1	Apuração - Ampliação do sistema de esgotamento sanitário - MG	p 1.1	
2	Apuração Denúncias - PMCMV	p 1.2	
3	Avaliação - Obras de distribuição de água e esgotamento sanitário	p 2.1	
4	Avaliação - Fiscalização no BPC	p 2.2	
5	Avaliação - ARG Fábrica de Software	p 2.3	
6	Avaliação - ARG Avançar Cidades	p 2.4	
7	Gestão Hídrica - Avaliação do Risco Hídrico - 1a Etapa exploratória	p 3.1	
8	Gestão Hídrica - CGMCD/DF	p 3.2	
9	Monitoramento PPP - STU/CBTU	p 4.1	
10	Mapeamento de Riscos Midades	p 5.1	
11	Apuração - Ginásio Poliesportivo - MG	p' 1.2_	
12	Avaliação - Adequação de trecho rodoviário - duplicação da BR-XXX/MG	p' 2.3_	
13	Avaliação - ARG obra Campus Universitário - MG	p' 2.4_	
14	Avaliação - ARG cronograma obra duplicação BR-YYY	p' 2.5_	
15	Atuação da Regulação - CFEM e TAH - 1a. etapa	p' 5.1_	
Add	Remove	Properties	Performances

Table 4.6 – Partial and overall value scores for the superintendent suggested projects (supported by M-MACBETH).

Table of scores

Likewise, the set of projects was evaluated by the stakeholders' groups in terms of doability, as presented in the Table 4.7a and Table 4.7b.

Table 4.7 – Partial and overall doability scores for audit projects according to the view of the audit coordinator (a) and of the superintendent (b) (supported by M-MACBETH).

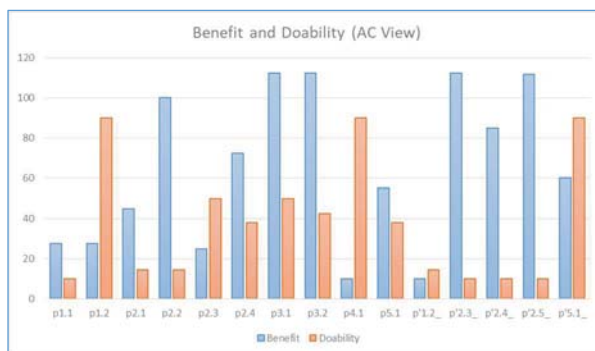
Options	Overall	capOp	HabTec	RecLogistics
p 1.2	90.00	90.00	90.00	90.00
p 4.1	90.00	90.00	90.00	90.00
p' 5.1_	90.00	90.00	90.00	90.00
[all upper]	90.00	90.00	90.00	90.00
p 2.3	50.00	90.00	10.00	90.00
p 3.1	50.00	90.00	10.00	90.00
p 3.2	42.50	40.00	10.00	90.00
p 2.4	38.00	10.00	10.00	90.00
p 5.1	38.00	10.00	10.00	90.00
p 2.1	14.50	40.00	10.00	10.00
p 2.2	14.50	40.00	10.00	10.00
p' 1.2_	14.50	40.00	10.00	10.00
p 1.1	10.00	10.00	10.00	10.00
p' 2.3_	10.00	10.00	10.00	10.00
p' 2.4_	10.00	10.00	10.00	10.00
p' 2.5_	10.00	10.00	10.00	10.00
[all lower]	10.00	10.00	10.00	10.00
Weights :		0.1500	0.5000	0.3500

(a)

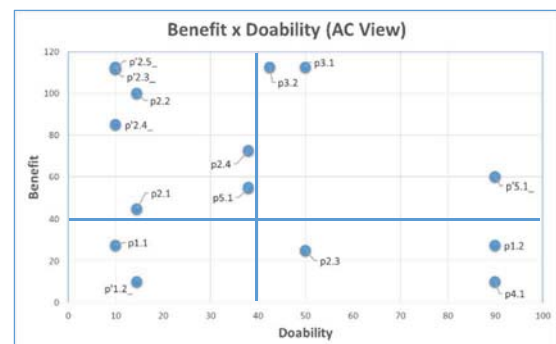
Options	Overall	capOp	HabTec	RecLogistics
p' 5.1	90.00	90.00	90.00	90.00
p 1.2_	90.00	90.00	90.00	90.00
[all upper]	90.00	90.00	90.00	90.00
p' 2.2	62.00	90.00	90.00	10.00
p' 4.1	50.00	90.00	10.00	90.00
p 2.3_	50.00	90.00	10.00	90.00
p 2.4_	38.00	10.00	10.00	90.00
p 5.1_	38.00	10.00	10.00	90.00
p' 1.1	14.50	40.00	10.00	10.00
p' 1.2	14.50	40.00	10.00	10.00
p' 2.1	14.50	40.00	10.00	10.00
p' 2.3	10.00	10.00	10.00	10.00
p' 2.4	10.00	10.00	10.00	10.00
p' 2.5	10.00	10.00	10.00	10.00
[all lower]	10.00	10.00	10.00	10.00
p' 3.1	-15.00	90.00	-120.00	90.00
p 3.2_	-22.50	40.00	-120.00	90.00
Weights :		0.1500	0.5000	0.3500

(b)

Afterwards one could obtain the portfolios generated for both stakeholder groups, with the benefit and doability graphs displayed in Figure 4.18 being generated: they order audit projects by benefit/cost ratio and identify dominance cases between audit projects, in order to support the negotiation phase. Thus, Figure 4.18 shows some instruments generated for the set of audit projects considered by the audit coordinator that participated in our case study, which are: Benefit and Doability Graph (Figure 4.18a); Benefit *versus* Doability Graph (Figure 4.18b); and, Audit Project Ranking (Figure 4.18c).



(a)



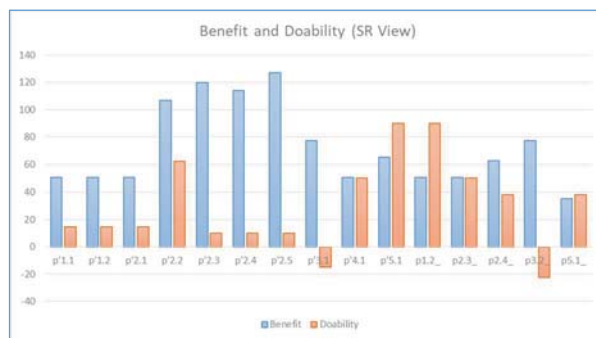
(b)

Ranking							
Benefit	Options	Doability	Options	Effort (100 - Doability)	Options	Ratio Benefit/Effort	Options
112,5	p3.1	90	p1.2	90	p1.1	6,00	p'5.1_
112,5	p3.2	90	p4.1	90	p'2.3_	2,75	p1.2
112,5	p'2.3_	90	p'5.1_	90	p'2.4_	2,25	p3.1
111,67	p'2.5_	50	p2.3	90	p'2.5_	1,96	p3.2
100	p2.2	50	p3.1	85,5	p2.1	1,25	p'2.3_
85	p'2.4_	42,5	p3.2	85,5	p2.2	1,24	p'2.5_
72,5	p2.4	38	p2.4	85,5	p'1.2_	1,17	p2.2
60	p'5.1_	38	p5.1	62	p2.4	1,17	p2.4
55	p5.1	14,5	p2.1	62	p5.1	1,00	p4.1
45	p2.1	14,5	p2.2	57,5	p3.2	0,94	p'2.4_
27,5	p1.1	14,5	p'1.2_	50	p2.3	0,89	p5.1
27,5	p1.2	10	p1.1	50	p3.1	0,53	p2.1
25	p2.3	10	p'2.3_	10	p1.2	0,50	p2.3
10	p4.1	10	p'2.4_	10	p4.1	0,31	p1.1
10	p'1.2_	10	p'2.5_	10	p'5.1_	0,12	p'1.2_

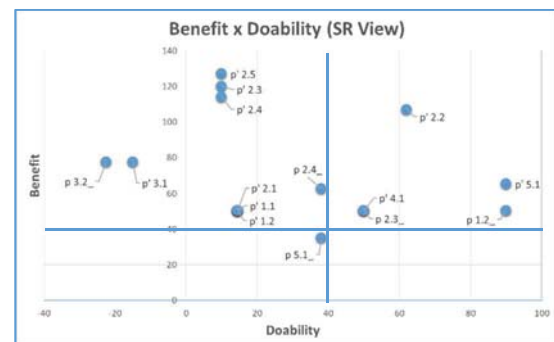
(c)

Figure 4.18 – Information to support negotiation according to the model of the audit coordinator.

Figure 4.19 shows the same instruments generated for the set of audit projects considered by the superintendent, which are: Benefit and Doability Graph (Figure 4.19a); Benefit *versus* Doability Graph (Figure 4.19b); and, Audit Project Ranking (Figure 4.19c).



(a)



(b)

Ranking							
Benefit	Options	Doability	Options	Effort (100 - Doability)	Options	Ratio Benefit/Effort	Options
127	p'2.5	90	p'5.1	122,5	p3.2_	6,53	p'5.1
120	p'2.3	90	p1.2_	115	p'3.1	5,03	p1.2_
114	p'2.4	62	p'2.2	90	p'2.3	2,82	p'2.2
107	p'2.2	50	p'4.1	90	p'2.4	1,41	p'2.5
77,5	p'3.1	50	p2.3_	90	p'2.5	1,33	p'2.3
77,5	p3.2_	38	p2.4_	85,5	p'1.1	1,27	p'2.4
65,25	p'5.1	38	p5.1_	85,5	p'1.2	1,01	p2.4_
62,5	p2.4_	14,5	p'1.1	85,5	p'2.1	1,01	p'4.1
50,25	p'1.1	14,5	p'1.2	62	p2.4_	1,01	p2.3_
50,25	p'1.2	14,5	p'2.1	62	p5.1_	0,67	p'3.1
50,25	p'2.1	10	p'2.3	50	p'4.1	0,63	p3.2_
50,25	p'4.1	10	p'2.4	50	p2.3_	0,59	p'1.1
50,25	p1.2_	10	p'2.5	38	p'2.2	0,59	p'1.2
50,25	p2.3_	-15	p'3.1	10	p'5.1	0,59	p'2.1
35	p5.1_	-22,5	p3.2_	10	p1.2_	0,56	p5.1_

(c)

Figure 4.19 – Information to support negotiation according to the model of the superintendent.

Since in our case study it was deemed as appropriate to use the prioritization approach for generating the portfolios, we have to choose projects by going through the list of best benefit/effort ratio until resources are exhausted. What we can read of these results is that the audit projects {p2.2; p3.1; p3.2; p5.1; p'2.4} have different results for each group, representing the greatest divergences between the stakeholder perceptions, as the audit projects are interesting only for one of the groups. The audit projects most valued by both models should continue in the portfolio, as in the case of the subset of audit projects {p1.2; p'2.3; p'5.1}. The remaining also must be negotiated, and as can be seen are {p1.1; p2.1; p2.3; p2.4; p4.1; p'1.2; p'2.5}. Thus, only the subset of audit projects that are valuable to both stakeholders did not need to be negotiated.

4.5.4. The Negotiation

The first action to begin the negotiation is the identification of divergences, in an attempt to cluster the audit projects according to the results of the evaluation models, as presented in the previous section, in order to facilitate the negotiation. This step is crucial and needs to be accomplished before proceeding. Identifying the areas of divergence between the set of the audit projects that the two stakeholders have defined, it was possible to map the performance and the values of these projects according to each model, as well as to generate the information to support the negotiation stage.

Table 4.8 below lists the audit projects eligible to compose the final portfolio, grouping the audit projects with greater divergence, the projects to be negotiated, and the suggestions of agreed projects

(according to the models). The greatest divergences occurred in the subset of audit projects whose ratings were above 50 points in terms of benefit and/or doability in the audit coordinator model and below 50 points in the superintendent model, or vice versa, showing the greatest differences in results according to each model. These projects are considered the most difficult to negotiate. Finally, the negotiable set consists of the rest of the audit projects. Considering S_t^- the subset of projects with the greatest divergence of values and not yet included in the portfolio at round t , S_t^+ is the subset with agreement between the parties to compose the portfolio at round t , and $S_t^\#$ the subset with the projects for negotiation. The distribution of audit projects in these sets supported the progress of the negotiation rounds described below. For our case study, the rounds took place in a half-session of decision conference, with the technological support and pre-structured negotiation templates was available. The two representatives met at this decision conference, using the necessary technological infrastructure, and discussed, negotiated and sought the best compromise solution. Since the superintendent was not geographically located near the audit coordinator, the decision conference session was delivered in a videoconference format.

Table 4.8 – Set of audit project selected to negotiation phase.

Options	Name	$S_t^- = \{\text{Greatest Divergences}\}$
p1.1	Apuração - Ampliação do sistema de esgotamento sanitário - MG	p2.2; p3.1; p3.2; p5.1; p'2.4
p1.2	Apuração Denúncias - PMCMV	
p2.1	Avaliação - Obras de distribuição de água e esgotamento sanitário	
p2.2	Avaliação - Fiscalização no BPC	
p2.3	Avaliação - ARG Fábrica de Software	$S_t^\# = \{\text{Negotiable}\}$ p1.1; p2.1; p2.3; p2.4; p4.1; p'1.2; p'2.5
p2.4	Avaliação - ARG Avançar Cidades	
p3.1	Gestão Hídrica - Avaliação do Risco Hídrico - 1a Etapa exploratória	
p3.2	Gestão Hídrica - CGMCID/DF	$S_t^+ = \{\text{Agreement of both}\}$ p1.2; p'2.3; p'5.1
p4.1	Monitoramento PPP - STU/CBTU	
p5.1	Mapeamento de Riscos Mcidades	
p'1.2	Apuração - Ginásio Poliesportivo de Juiz de Fora	
p'2.3	Avaliação - Adequação de trecho rodoviário - duplicação da BR-XXX/MG	
p'2.4	Avaliação - ARG obra Campus Unversitário - MG	
p'2.5	Avaliação - ARG cronograma obra duplicação BR-YYY	
p'5.1	Atuação da Regulação - CFEM e TAH - 1a. Etapa	

• Round 0:

Before starting the negotiation, the negotiation checklist points were defined, as well as the trade-offs between the audit projects, in terms of execution and expected benefit, according to the view of each representative, were displayed (Figure 4.18 and Figure 4.19).

Also defined were the audit projects that each party would not give up to execute, whose subsets were defined as BATNA for each one. Namely, as pointed out by the audit coordinator that the execution of projects related to the tactical theme of water management and software factory were essential for the evaluation of policies in the defined issues. Thus, the subset $S_{BATNA}^1 = \{p3.1; p3.2; p2.3\}$ was defined for its BATNA. On the other side, the superintendent exposed that he considered some projects essential to be executed by his team this year, defining the following $S_{BATNA}^2 = \{p'2.3; p'2.5; p'5.1\}$.

Finally, the breakdown conditions were defined and the rounds could begin.

• Round 1:

The first and simplest question asked by the mediator was to confirm the set of audit projects that both models considered eligible for the portfolio. Once these were validated by the two representatives, these projects could already be considered as approved for the portfolio.

In spite of the subset of audit projects $\{p1.2; p'2.3; p'5.1\}$ having received high ratio benefit/effort value from both representatives, it should be noted that audit project p1.2 was not in the initial set of the superintendent and audit projects p'2.3 and p'5.1 were not in the initial set of the audit coordinator. Thus, from the outset, the methodology was able to identify important new audit projects for both that had not yet been raised by one of the parties. Therefore, the negotiation began with the mediator highlighting this result for this subset of audit projects and seeking confirmation from those involved about the importance and agreement of maintaining this subset in the portfolio. Both parties agreed and validated the suggestion.

At this point, representatives had not discussed the other subsets of projects, so one had:

$$S_1^+ = \{p1.2; p'2.3; p'5.1\}$$

$$S_1^- = \{p2.2; p3.1; p3.2; p5.1; p'2.4\}$$

$$S_1^\# = \{p1.1; p2.1; p2.3; p2.4; p4.1; p'1.2; p'2.5\}$$

• Round 2:

In a structured way, negotiation began with each of the representatives taking into account the information for negotiation from the opponent, as shown in Figure 4.18 and Figure 4.19. They also had knowledge of each other's BATNA, which were $S_{BATNA}^1 = \{p3.1; p3.2; p2.3\}$ for the audit coordinator and $S_{BATNA}^2 = \{p'2.3; p'2.5; p'5.1\}$ for the superintendent. Thus, the audit coordinator knew the results and preferences of the superintendent and vice versa. The communication was established during the decision conference and text message exchanges were registered in the CGU project management system.

After that, the audit projects that were in the BATNA of each representative were explored, so that each party argued about the technical grounds to want to execute those projects. The superintendent was able to convince the audit coordinator that the audit project p'2.5 was relevant and worth being in the portfolio. The audit projects $\{p'2.3; p'5.1\}$ had already appeared in the subset of audit projects with the best benefit/effort ratio for both. In turn, at first, the audit coordinator was only able to convince the superintendent to add the project p2.3 to the portfolio.

At this point, we had:

$$S_2^+ = \{p1.2; p2.3; p'2.3; p'2.5; p'5.1\}$$

$$S_2^- = \{p2.2; p3.1; p3.2; p5.1; p'2.4\}$$

$$S_2^\# = \{p1.1; p2.1; p2.4; p4.1; p'1.2\}$$

• Round 3:

During the next iteration, it was possible to observe bargaining steps with the presence of concessions and trade-offs to reach a compromise solution. The audit coordinator also made use of logrolling to search projects that were less important and that could be offered in an exchange. This was the case of projects p3.1 and p3.2 in the audit coordinator set, related to a tactical theme, and which at first was not considered a priority according to the superintendent's model. In the view of the audit coordinator, this project deserved more prominence, a fact that culminated in exchanges of messages arguing the different points of view. At the end of the discussion, they agreed to execute the audit project but with the support of the team from another regional office that already has expertise on the subject, so that there could be gains for both sides, characterizing an integrative negotiation.

The participants also made analyses and discussed the remaining audit projects with great divergences, based on the benefit and doability graphs. They realized that the project p5.1 brings a very low benefit and the projects p1.2 and p2.4 would require a lot of effort for execution (low

doability) and resolved to exclude them from the portfolio. In terms of benefit, projects p1.1 and p2.1 also would not bring so much benefit from the effort required. In this sense, they after all, reached the following compromise solution within that set: {p1.2; p2.2; p2.3; p2.4; p3.1; p3.2; p4.1; p'2.3; p'2.5; p'5.1}.

At the end, we have:

$$S_3^+ = \{p1.2; p2.2; p2.3; p2.4; p3.1; p3.2; p4.1; p'2.3; p'2.5; p'5.1\}$$

$$S_3^- = \{p1.1; p2.1; p5.1; p'1.2; p'2.4\}$$

$$S_3^\# = \{ \}$$

As noted in the final compositions of the sets, the representatives came to an agreement and did not need to use an arbitrator. Nonetheless, in cases of need for deliberation for not consensual projects, it was agreed that the divergences would be taken for deliberation by the arbitrator (The Federal Secretary of Internal Control in our case study). In our example it was not necessary trigger the arbitrator. If that had been the case, the decision of the arbitrator would be binding, in the sense that the parties must accept it independently of any reluctant side. However, the arbitrator's decision should also be based on structured information.

4.5.5. Feedback on the Participatory Process

In order to collect the perceptions about the whole participatory process, we designed a survey to the participants with the aim to obtain their insights about the proposed methodology. The survey was conducted through semi-structured interviews.

The survey, developed using the Likert-scale, sought to bring the perception of those involved in the study as to the aspects: the overview of the doctoral proposal, in terms of the multicriteria methodology and the informed negotiation framework; the participatory process; and, the integration of the methodology with CGU corporate systems.

We obtained response from eight of a universe of the eleven participants (six audit coordinators and five superintendents) and the results were consolidated, in terms of percentage of participants' responses, in the table below. They also had the opportunity to write open question comments at the end of the survey.

(*)					SD	D	NAD	A	SA
Aspect 1 - Overview of the Doctoral Proposal - Multicriteria Methodology / Informed Negotiation Framework									
Presentation of the study proposal									
I had a clear idea about the proposal of the doctoral study in reference.								12,5%	87,5%
The material prepared to inform about the methodology developed in this study was attractive and informative.								50%	50%
Applicability of the methodology in the context of CGU									
Currently the CGU is identified need for support tools for dissolution of differences or conflicts between internal organizational units.								25%	75%
The methodology developed has the potential to improve CGU's decision-making processes.								12,5%	87,5%
I can identify other scenarios in which the methodology could be extended and applied within the CGU.							12,5%	62,5%	25%
Aspect 2 - Participatory Process									
The participatory sessions were enriching for the knowledge and appropriation of the developed methodology.								50%	50%
The material prepared for the participatory sessions was clear and helped in the construction and validation of the group models.								62,5%	37,5%
A true communication process took place between participants.								12,5%	87,5%
I changed my opinion in some questions, considering other participants' answers.								75%	25%
I believe that the final approved models are representative for the group when planning the audit projects to elaborate the operational plan								50%	50%
The decision support systems (M-MACBETH) assisted a sound interpretation of results.								25%	75%
The negotiation supported by the information about the perceptions of both parties makes it considerably easier to reach a compromise.								62,5%	37,5%
The facilitator maintained a good level of communication during and between sessions and clarified all the doubts that arose.									100%
Aspect 3 - Integration of the methodology with CGU corporate systems									
The presented methodology is friendly and has the potential to be transformed into a decision support system (DSS).								37,5%	62,5%
The implementation of a DSS should consider the integration to CGU's corporate systems (CGUProj; e-AUD, etc).								25%	75%
I believe that this DSS will contribute to the allocative efficiency of the resources available to CGU.								12,5%	87,5%

* SD = Strongly Disagree, D =Disagree, NAD = Neither Agree or Disagree, A = Agree, and SA =Strongly Agree

Following are some comments made by participants:

"I have already had conflicts over the choice and decision of some control actions to be carried out by the CGU Regional Superintendencies, where the difficulties were not very clear. With this methodology, this conflict would be better managed and understood by CGU's audit coordinations, whose final results of the work planning process would be optimized objectively and serenely."

"I would like to know what type of decision making the methodology is best applied to, for example: operational, tactical or strategic planning."

What we can see from reading these results is that there was a very positive feedback regarding the whole process, and that the methodology is supported by CGU decision-makers. They believe that the methodology can be applied and extended to other contexts (for instance in supporting the preparation of tactical and strategic plans), and that the participatory process is essential for its implementation. Finally they considered that the proposed methodology has potential for integration within CGU's internal corporate systems. The implementation of a DSS module, integrated with CGU corporate systems and the functionalities of the methodology presented, can bring improvements in decision making processes and efficiency in the allocation of resources and expected results.

4.6. Discussion

With regard to the methodological aspects of the proposed methodology, the integration of MCDA with negotiation proved to be a rich path to be explored. By combining multicriteria methodology with negotiation tools and techniques, it was possible to build multicriteria resource allocation tools that support the negotiation process in a shape of an informed negotiation framework. Thus, in terms of contribution to literature, we can mention that we explored the use of multicriteria models and tools in a negotiation context. Therefore, we could show a constructive process that, reflecting on the decision problem faced and considering the CGU stakeholders preferences provides a basis for building models of the problems through different views. In the context of the CGU, the study contributes as a transparent and structured way of the ostensive use of scientific methods to overcome divergences or conflicts when preparing their operational plan, which goes from the structuring phase of multicriteria models to the evaluation of audit projects and negotiation to be performed.

The suggested process – underlying the proposed methodology – departure from the multicriteria portfolio modelling, following the evaluation and analysis of the results and aiming at an informed negotiation. The group models built during the process should be meaningful to any representative of these groups, whose perceptions should be reflective in the models. As with the case study presented, all CGU audit coordinators should make use of their corresponding group model to evaluate their audit projects. The same is true for superintendents. Thus, any two representatives from each group who disagree on the audit projects to be executed can use this information generated by

the two models to begin the negotiation step, which will always occur in pairs by the proposed methodology, in search of a compromise solution.

With regard to the application of the methodology, the greatest difficulties and also the big gains identified throughout the process were related to the importance of the social process grounded in good decision support techniques. Reconciling the agendas of those involved was not an easy task, as well as there were challenges in aligning and levelling the knowledge of those involved. However, the satisfaction and belonging of all stakeholders who supported the case study were notorious. It became clear that when the top management participates in the model building process, it is much easier to appropriate the methodology and consider it as important for continuous improvement of internal processes in the organization.

On the other hand, another point that cannot be ignored was the long period between the beginning of the iterations with the CGU stakeholders and the conclusion of the negotiation stage. However, in the scope of this thesis this was justified by the need to improve the methodology throughout the whole process. For the next uses of the proposed methodology it should be implemented in a shorter period.

For all the above, was noticed that, before this study, CGU managers' decisions were based only on their personal perceptions regarding the "importance" and available operational capacity, i.e. their planning were done in an *ad hoc* way. Now, with the use of instruments to support the decision and the application of integrative negotiation techniques, they recognised a higher robustness in the CGU decisions.

Finally, it is worth mentioning that this work is based on negotiation in peer relationship, between one representative of each group, which means the negotiation occurs in pairs, working on a common set of project defined for these representatives (as graphically presented in Figure 4.1). Therefore, it might be interesting to search ways to negotiate with more actors involved at the same time, in order to optimize the time of those involved, decrease the number of negotiation sessions, and reach a global solution commitment. It may also be interesting to develop better negotiation templates. These are suggestions for future work.

Therefore, we obtained rich feedback from the participants, who felt that they belonged to the whole process, considered it easy to understand, and perceived the potential for using structuring and sound evaluation techniques in other contexts. The participants' perception is that the presented methodology is user-friendly and has the potential to be transformed into a DSS module integrated

within CGU's corporate systems. The suggested DSS has the potential to contribute to the allocative efficiency of resources available to the CGU. This will be explored in Chapter 5.

Chapter 5 ENHANCING NEGOTIATION WITHIN

MULTICRITERIA RESOURCE ALLOCATION IN AUDITING:

DESIGNING A DECISION SUPPORT SYSTEM FOR CGU

The aim of this chapter is to introduce the concept of Decision Support System (DSS) and explore how to improve CGU's corporate system to enhance negotiation within multicriteria resource allocation concepts that were developed in the previous chapters. The following research was carried out based upon a rationale: CGU makes use of several corporate systems to support the planning and execution of its activities and to store the relevant data relating to its audit projects. The CGU corporate audit project management system is currently being remodelled and a new audit system is being implemented in the organization. Supported by the DSS literature, and through interviews and meetings with the CGU Auditing Issues Innovation Coordination, as well as based on the methodology developed in the previous chapters of this thesis, we present a proposal for DSS architecture to be implemented and integrated into the CGU's new corporate auditing system. This DSS module aims to enable improvements in the architecture of existing systems in CGU so as to enable multicriteria negotiation, specifically providing interactive and flexible mechanisms/instruments for stakeholders to analyse relevant data and making choices about the type of audit projects that should be executed, as well as to analyse the generated portfolios and to support negotiation.

5.1. Introduction

Multicriteria resource allocation methodologies have been recognized to be valuable for an auditing context and the development of DSSs to assist the planning and execution of organizations activities is essential to bring efficiency in fulfilling the mission of the organizations. According to Turban et al. (2005, p. 105), a *“DSS is an approach (or methodology) for supporting decision-making. It uses an interactive, flexible, adaptable computer-based information system especially developed for supporting the solution to a specific non-structured management problem. It uses data, provides an easy user interface, and can incorporate the decision-maker's own insights.”*

The objective of this study is to design a DSS module architecture that helps implementing the methodology developed in the previous chapter. In Chapter 4, a methodology based upon multicriteria

resource allocation techniques was developed to support the selection of audit projects and to deal with cases of conflicts of interest in audit resource allocation decisions. Specifically, it was designed and tested a socio-technical approach addressing the development of multicriteria resource allocation tools to assist stakeholders in selecting audit projects within negotiation perspective.

In order to collect the perceptions about the whole participatory process, a survey was carried out to participants to get their insights about the proposed methodology. As a result: 62,5% of survey's participants strongly agreed that the methodology was user friendly and had the potential to be transformed into a DSS; 87,5% of survey's participants believed that such a DSS would contribute to the allocative efficiency of the resources available to CGU; and, there is a willingness from CGU decision-makers to make use of such a DSS.

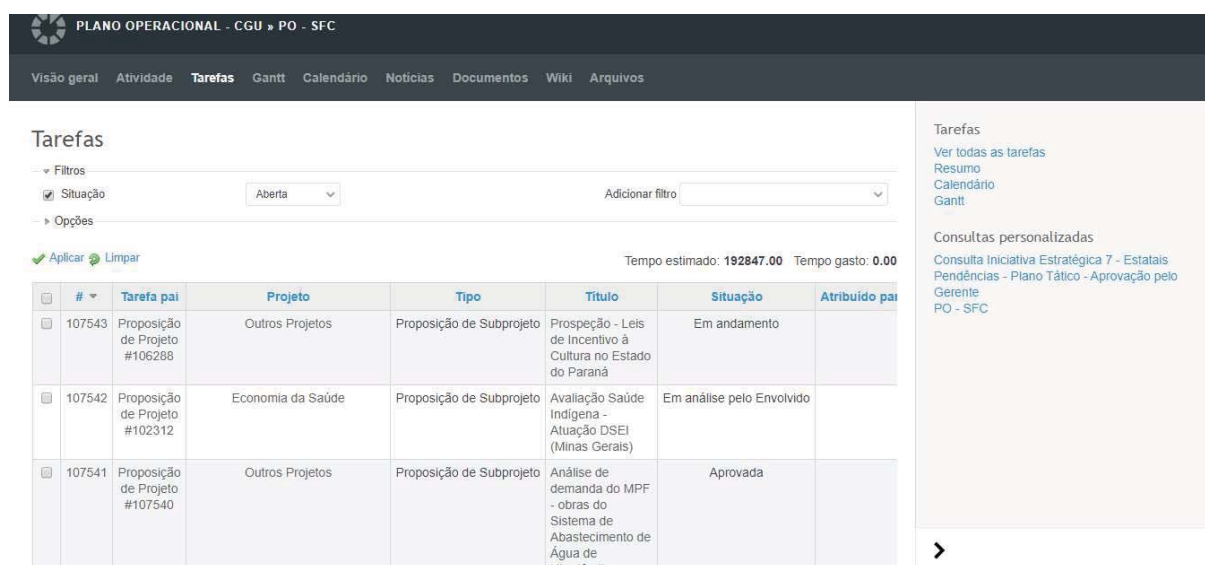
This chapter reports the development of the architecture of the DSS, as is structured as follows: in the next section, background information about the current processes and corporate systems used at CGU is provided. Section 5.3 presents the literature review related to DSSs. Section 5.4 describes the methodological proposal of module architecture to integrate with the existing system and finally, in Section 5.5, some discussion and final remarks are provided.

5.2. Background Information

CGU's corporate systems support the organization's planning and execution activities. Currently, SFC makes use of the 'CGUProj System' (Figure 5.2 and 5.2), a software based in Redmine technology, to plan, record and execute its Operational Plan. As explained in Section 3.2.1 (Chapter 3), the current elaboration of SFC Operational Plan is defined in three negotiation rounds. In the first, are defined the audit projects that necessarily need to be executed, under established in legislation, regulations or agreements, with a fixed term. In the second round, audit projects are proposed regarding priority themes defined by the board of directors. In the third round, the remaining audit projects are planned on topics that are of interest to some audit coordination or superintendence but were not prioritized by the board of directors.

The flow for planning audit projects at CGU currently occurs as follows: the proposer, who may be the audit coordinator or the superintendent, proposes the audit projects to compose the Operational Plan. The execution of an audit project may involve teams from outside the audit unit (audit coordination or superintendence) that proposed the audit project. In this case, still in the planning phase, it will be necessary to obtain the agreement of the other area involved. If the teams involved do not agree with the proposal, there is negotiation between them with a view to agreeing

the necessary adjustments. In case of not reaching a consensus, it is submitted to the analysis and deliberation of the board of directors. Nevertheless, this entire process is being discontinued and a new corporate system is being developed by the CGU Auditing Issues Innovation Coordination.



PLANO OPERACIONAL - CGU » PO - SFC

Visão geral Atividade **Tarefas** Gantt Calendário Notícias Documentos Wiki Arquivos

Tarefas

☐ Filtros
☒ Situação Aberta Adicionar filtro
☐ Opções
☒ Aplicar ☐ Limpar

Tempo estimado: 192847.00 Tempo gasto: 0.00

#	Tarefa pai	Projeto	Tipo	Título	Situação	Atribuído pai
107543	Proposição de Projeto #106288	Outros Projetos	Proposição de Subprojeto	Prospecção - Leis de Incentivo à Cultura no Estado do Paraná	Em andamento	
107542	Proposição de Projeto #102312	Economia da Saúde	Proposição de Subprojeto	Avaliação Saúde Indígena - Atuação DSEI (Minas Gerais)	Em análise pelo Envolvido	
107541	Proposição de Projeto #107540	Outros Projetos	Proposição de Subprojeto	Análise de demanda do MPF - obras do Sistema de Abastecimento de Água de Ilhabela	Aprovada	

Tarefas
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[Gantt](#)
 Consultas personalizadas
[Consulta Iniciativa Estratégica 7 - Estatais](#)
[Pendências - Plano Tático - Aprovação pelo Gerente](#)
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Figure 5.1 – CGU's current corporate audit planning system – CGUProj (in phase of discontinuation). General screen showing the audit projects of a given organizational unit. Illustrative example.



PLANO OPERACIONAL - CGU » PO - SFC » 3. PROJETOS COMPLEMENTARES » AVALIAÇÃO

Visão geral Atividade **Tarefas** Gantt Calendário Arquivos

Proposição de Subprojeto #101473

☐ Observar

Proposição de Projeto #101194 Promoção, Proteção e Recuperação da Saúde Indígena - DSEI/TO
Fiscalização DSEI/TO - Promoção, proteção e recuperação da saúde indígena
 Adicionado por **Leandro Da Cruz Alves** 5 meses atrás. Atualizado 8 dias atrás.

Situação:	Aprovada	Início:	15/07/2019
Prioridade:	Normal	Data prevista:	30/09/2019
Atribuído para:	CGUTO - Supervisores		
1ª Repactuação:		HH planejado - PO 2018:	0
2ª Repactuação:		HH realizado - PO 2018:	
3ª Repactuação:		Orçamento Previsto - 2018:	0.00
4ª Repactuação:		Despesa Executada - 2018:	
Propositor:	CGUTO	Data de Conclusão Efetiva:	
Executor:	CGUTO	Tarefa PO anterior:	
Envolvido:	SFC/CGSAU	Ação(ões) de Controle(s) - OS:	
HH planejado - PO 2019:	400	Divisão/Núcleo:	
HH realizado - PO 2019:			
Orçamento Previsto - 2019:	0.00		

Tarefas
[Ver todas as tarefas](#)
[Resumo](#)
[Calendário](#)
[Gantt](#)

Figure 5.2 – Audit project and audit subproject detailing, containing involved man-hour and financial resources – CGUProj (in phase of discontinuation). Illustrative example.

CGU is now completing the development of a new platform for planning, execution and monitoring of its audit projects, named 'e-Aud'. The system e-Aud follows standards of Project Management Institute (PMI) and establishes a new flow, presented in Figure 5.3, for the elaboration of the CGU Operational Plan. First, the audit projects eligible to compose the Operational Plan are identified, in terms of mandatory activities, auditing universe, external demands, audit trails and others. Following, the audit projects are categorized according to the criteria defined, the resources required are estimated and the projects are grouped according to the purpose. An analysis of the proposal portfolio is then performed, allocating the resources in mandatory, priority and complementary projects (in the latter, if applicable) and detailing available capacity. Next, a portfolio balancing, with definition of audit project prioritization criteria and allocation of resources in the selected projects, is performed. Finally, the Operation Plan is updated and the responsibilities of each team involved is defined. The new interface of e-Aud is presented in Figure 5.4. It is important to clarify that the system presented in Figure 5.4 was developed by the CGU Auditing Issues Innovation Coordination team and initially it was not influenced by the work carried out in this PhD study. However, this new e-Aud was taken as the starting point for designing the new negotiation module proposed in this chapter (and in this case influenced by the results of the doctoral study).

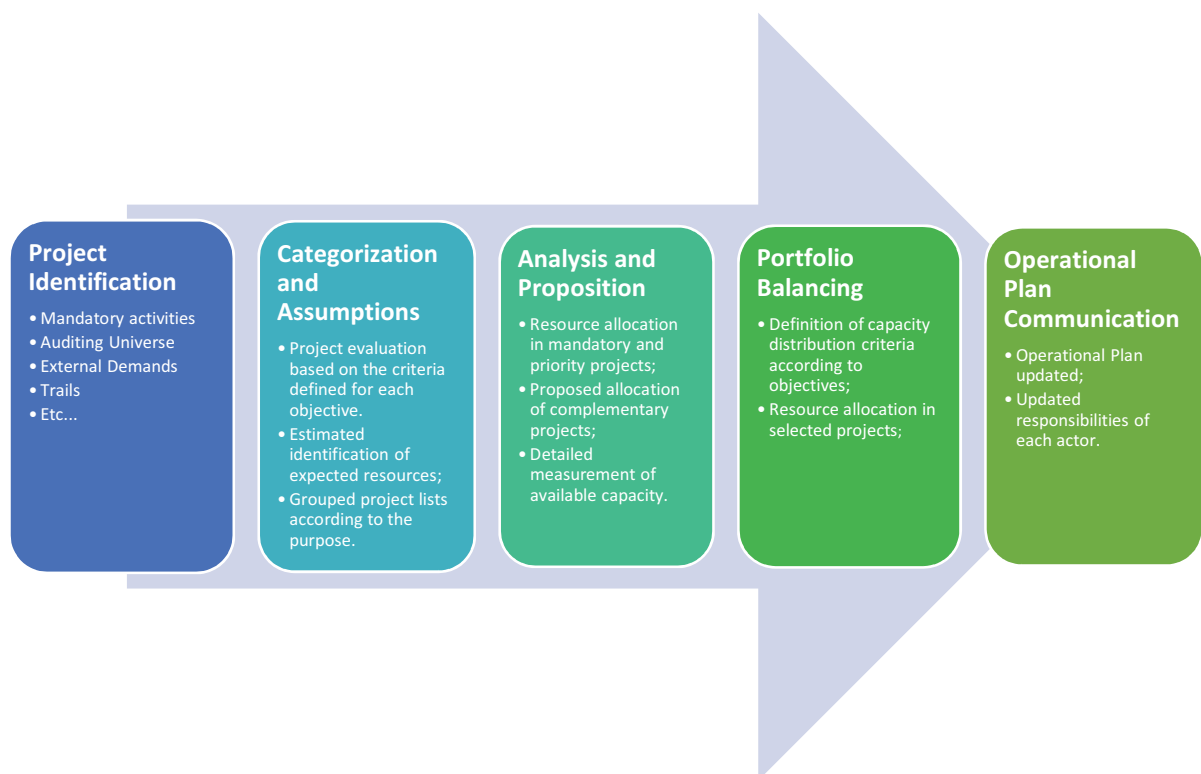


Figure 5.3 – New flow for the elaboration of the Operational Plan – ongoing implementation by the *CGU Auditing Issues Innovation Coordination*.

Planos de Trabalho do Plano Operacional

Disponível: 1888

Disponível: 0,00

Alocado: 1900

Alocado: 0,00

Linha de Base de H/H

Linhas de Base de H/H

Linhas de Base Financeira

Id	Título	Situação	H/H Total do Plano de Trabalho	H/H Alocado	Custo do H/H Total	Recursos Financeiros (R\$) do Plano de Trabalho	Total de Desembolsos	E Gantt	
#781681	Projeto L	Em Execução	1000	1000	193.530,00	6.000,00	0,00	<div></div>	<div></div>
#781687	Projeto K	Em Edição	100	100	19.353,00	50.000,00	0,00	<div></div>	<div></div>
#781676	Projeto B	Em Edição	40	40	7.741,20	0,00	0,00	<div></div>	<div></div>
#781678	Projeto X	Em Edição	600	600	116.118,00	4.000,00	0,00	<div></div>	<div></div>
#781679	Projeto W	Em Edição	160	160	30.964,80	0,00	0,00	<div></div>	<div></div>
			1900	1900	367.707,00	60.000,00	0,00		

Informe um Plano de Trabalho

Figure 5.4 – The new CGU Corporate Audit System (e-Aud) under development by CGU. Illustrative screen with the registration of a proposal of audit projects to compose the Operational Plan, with definition of financial and human resources involved on each audit project.

In the previous chapter, a socio-technical proposal to help CGU stakeholders reach a compromise solution on the portfolio of audit projects was developed, being based on an informed negotiation framework. The methodology presented included, within a participatory process, the support for structuring of multicriteria models to audit project evaluation, the support for the definition of audit project portfolios and the support for negotiation in the contexts of divergence of views and opinions. Thus, a DSS module that makes use of the data available in CGU's corporate audit systems, which incorporates the MRAMs developed in previous studies and that supports informed negotiation between stakeholders, can be promising to bring improvements to CGU's internal processes.

5.3. Review of Concepts

Focusing on the concepts of DSS and how to design a DSS architecture, a review of concepts was performed. Specifically, it aimed to inform about the main concepts and requirements of a DSS, as well as to review articles that inform about how to design DSS architecture.

The key concepts that make up a DSS are the Data Subsystem, the Model Subsystem and the User Interface System, as shown in Figure 5.5. The Data Subsystem contains data from various sources, including internal data from the organization, as well as the data generated by different applications or external sources. Model Subsystem consists of various mathematical and analytical models that are used to analyse the data, thereby interrelate these models with appropriate linkages through the database, producing the required information. And, the User Interface System is an interactive graphical interface which makes the interaction easier between the DSS and its users, displaying the results (output) of the analysis in various forms, such as graphics, charts, text or plotters (Sprague, 1980).

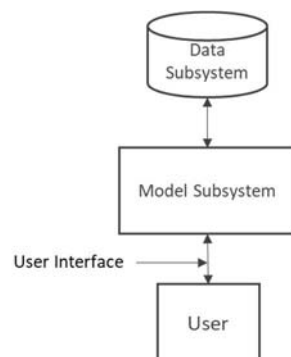


Figure 5.5 – Generic scheme of a DSS - based on Sprague (1980).

We started our review by searching articles that report DSS models and architectures in resource allocation and/or negotiation situations. Our search protocol focused on combinations of several keywords – “Decision Support System”, “DSS model”, “DSS architecture”, “DSS framework”, “portfolio”, “multicriteria decisions”, “negotiation” – in the data sources B-on Web of Science, ScienceDirect, and SCITEPRESS Digital Library. The research reference period was July 2019. The following text gathers informed deemed as relevant from the collected studies.

According to Sprague (1980), from the manager/user point of view, some concepts should be in mind when developing a DSS. The DSS should provide support: for decision making, but with emphasis on semi-structured and unstructured decisions; for managers at all levels, assisting in integrating between the managers dealing with related parts of a larger problem whenever appropriate; for decisions which are interdependent, as well as those that are independent; for all phases of the decision making process. Moreover, it should be easy to use.

Miah et al.(2012) presented a development-oriented DSS approach to evaluate design qualities specific to a DSS, using the framework shown in Figure 5.6 with six activities, and determined evaluation checkpoints. This framework follows a socio-technical perspective. The first activity is related to the decision problem and brings reflections on problem importance, suitability for decision-makers and problem complexity/ simplicity. The second activity defines design objectives in terms of quantitative or qualitative measures to be used, suitability of objectives, and resources required by design objectives. In the third activity, the design and development artifacts are defined, and there is a focus on the adopted design and development approach and on the measures used to determine the innovative issues of the system. In the fourth activity is determined the context in which the system should be used and further tested. The fifth activity focuses on measuring effectiveness and efficiency within the context of system application. And finally, the sixth activity brings reflections on communication of results, in terms of communication structure and how the outcomes are to be presented.

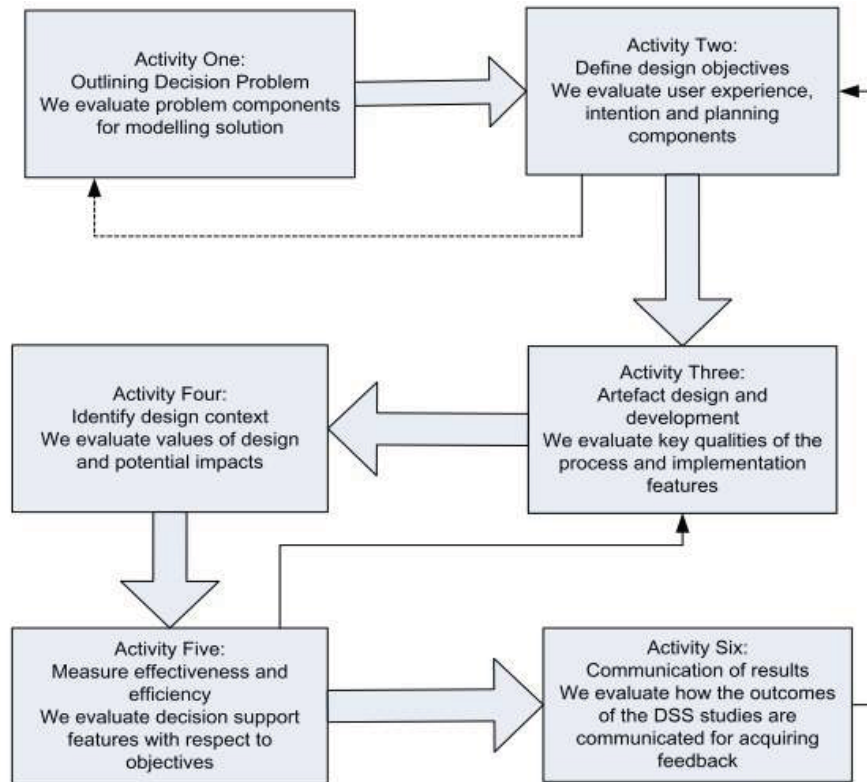


Figure 5.6 – Development oriented DSS evaluation framework (source: Miah et al., 2012)

Agrahari and Tripathi (2012) showed a theoretical framework for the development of a DSS for agriculture. The authors highlighted the importance and benefits of collaborative relationships between scientist and stakeholders through participatory research and development, and suggested a DSS to make agriculture science more accessible to farmers and extension officers.

Felsberger et al. (2017) presented a review of DSSs for manufacturing systems. The authors highlighted that DSS are about developing and deploying IT-based systems to support decision processes and can be considered as interactive computer information systems that solve the problems of non-structures and can help decision-makers to use data and models. And the differentiation of the type of DSS (passive, active and cooperative) was also highlighted. A passive DSS supports the decision-making process, but without producing decision suggestions or solutions while an active DSS is capable of providing such suggestions; and a cooperative DSS allows the decision-maker to interact with the system, to modify, complete, or refine the decision recommendations presented by the system, before sending them back to the system for validation.

In terms of DSS application development, Felsberger et al. (2017) also brought structuring concepts about the modules of a DSS (which refer to a framework like Figure 5.7) that we highlight

some of them below, namely: model-driven DSS, data-driven DSS and communication-driven DSS. A model-driven DSS is typically designed for user to model parameters and, through analytical, financial, optimization, and algebraic decision simulation models, to assist decision-makers in analysing a given situation. Usually it is not data intensive. A data-driven DSS enables structured data access and manipulation and can handle both internal and external data sets of the organization's enterprise systems and real-time data. A communication-based DSS seeks to create an environment for resource and information sharing, collaboration and communication, and relies on hybrid networking and electronic communication technologies to connect decision-making groups.

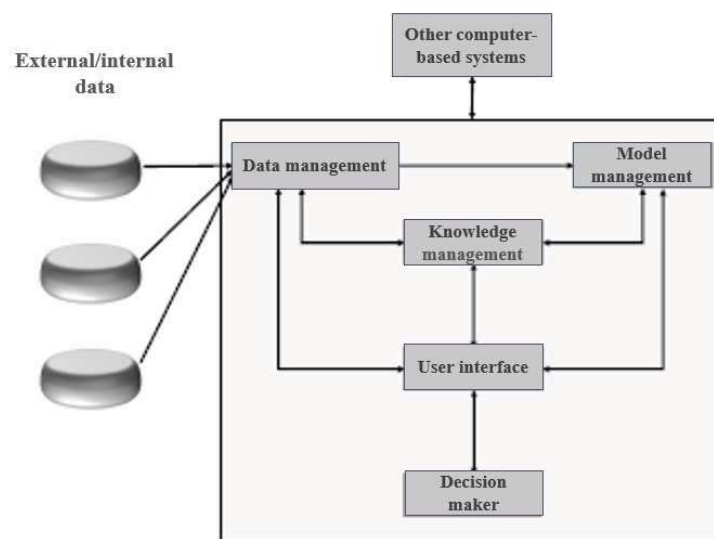


Figure 5.7 – Schematic view of DSS components (source: Felsberger et al., 2017).

Archer and Ghasemzadeh (1999) developed an integrated framework for project portfolio selection (Figure 5.8), which separates the work into distinct stages, and a prototype system is described to implement the framework in the form of a DSS. Each stage accomplishes a particular objective and creates inputs to the next stage. According to the authors, a DSS for project portfolio selection should include a project portfolio database management module, a model management module (to support the techniques or models to be used) and a user interface to interacting with the model management and database management modules (Figure 5.9).

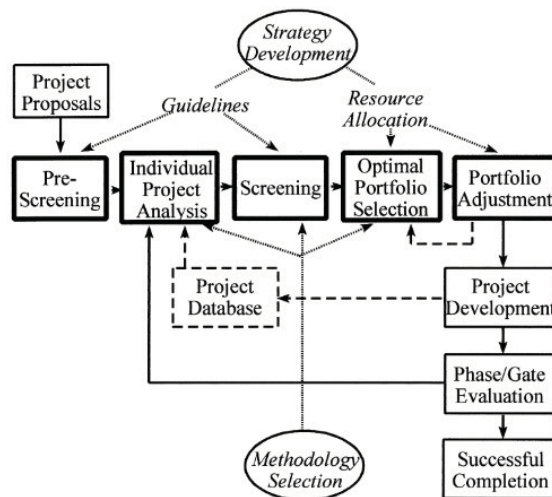


Figure 5.8 – Framework for Project Portfolio Selection (source: Archer and Ghasemzadeh, 1999).

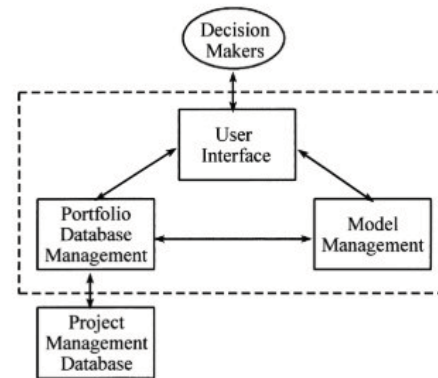


Figure 5.9 – Project Portfolio Selection Decision Support System (source: Archer and Ghasemzadeh, 1999).

Ghasemzadeh and Archer (2000) also brought some remarks when considering a DSS to support project selection. They emphasized the importance of continuous interaction between system and decision-makers in all stages of the portfolio selection process, since the system provides data and models to support the decision process. Also, they highlighted how difficult is to formulate explicitly in advance all of the preferences of the decision-makers, so that interactive decision-making has been accepted as an appropriate way to obtain the preferences of decision-makers. Besides that, the involvement of decision-makers in the solution process indirectly takes successful implementation of the solution. This type of interaction, supported by a computer-based system, with a subsystem to manage the related techniques/models, another subsystem to support the data needs, and a subsystem as an interface between the decision-maker and the system, is equivalent conceptually to a DSS.

We also identified some studies targeted for negotiation supported by DSS, such as the MARS approach in the verbal and holistic evaluation of the negotiation template (Górecka et al., 2016). In this study, the authors made use of negotiation offer scoring system: simple additive weighting (SAW) method supported by the user interface of negotiation system and illustrated an initial stage of the negotiation process, in which two offers were submitted at the negotiation table, one by each of the parties.

A comparative study of negotiation DSSs was presented by Bellucci and Zeleznikow (1998). They pertinently mentioned that a decision support negotiation system is a system which supports negotiation in the same way to a traditional negotiation support system (NSS), however by analysing

the targets and needs of the parties and by interpreting past offers and counteroffers by each one, the system is able to propose sample settlements. In terms of modelling issues for building negotiation DSSs, the authors stressed that the modeller should consider two main issues: the negotiation strategy, to help identify the stages in negotiation and to conduct negotiators towards agreement; and, the relationship between the issues under investigation to identify the effect and importance of issues on each other, to determine the type of solution that would most likely be accepted.

Table 5.1 summarizes key aspects from the reviewed studies that may be specifically useful to the design a DSS to enhance negotiation within audit context through multicriteria resource allocation instruments.

Table 5.1 – Key aspects from reviewed studies about DSS.

Reference	Main Field of Knowledge	Area of study application	Study features with special relevance for a negotiated selection of audit projects
Sprague (1980)	Management Information Systems	Systems Development	Concepts to develop a Decision Support System (DSS)
Miah et al.(2012)	Information Systems	Evaluation Methods	Development-oriented approach for evaluating DSS applications
Agrahari and Tripathi (2012)	Engineering and Science	DSS for Agriculture	Theoretical framework for development of DSS
Felsberger et al. (2017)	Decision Support System	Manufacturing Systems	Structuring concepts about the modules of a DSS: Model-driven DSS; Data-driven DSS; Communication-driven DSS.
Archer and Ghasemzadeh (1999)	Project Management	Project Portfolio Selection	Project Portfolio Selection Decision Support System
Ghasemzadeh and Archer (2000)	Project Management	Project Portfolio Selection	Remarks when considering a DSS to support project selection
Górecka et al. (2016)	Group Decision Negotiation	Supporting Negotiation	Negotiation supported by DSS
Bellucci and Zeleznikow (1998)	Negotiation Support Systems (NSS)	Comparative Study of NSS	Modelling issues for construction of negotiation decision support systems

From all of the above, it is observed that for the design of a DSS that supports the CGU in its audit project selection context, the following aspects should be considered: data management, user interface and model management. Variations of these pillars can be observed throughout the studies, including the inclusion of negotiation features, as in the case of the negotiation support systems. In the next section, we will present how CGU's corporate systems is currently structured along these lines, as well as the proposed architectural model for an integrated DSS that takes into account negotiation within multicriteria resource allocation in auditing (taking into consideration the research earlier developed in this thesis).

5.4. DSS Module Architecture Proposal to CGU Corporate System

Adopting the framework for DSS design proposed in Miah et al.(2012), the six stages and correspondent checkpoints were followed, through meetings and interviews with the coordinator of Prospecting and Innovation area in CGU, so that the proposal DSS module requirements to CGU Audit Corporate System could be planned. In order to facilitate the understanding of the application of stages and checkpoints of the adopted framework from (Miah et al., 2012), Table 5.2 portrays key aspects of the suggested module for CGU, following the sequence presented in Figure 5.6.

Table 5.2 – DSS framework followed to design the DSS Module for the CGU Corporate System.

	Considerations for correspondent checkpoints
1. Outline the decision problem	
a) Problem importance b) Problem suitability for decision-makers c) Problem complexity / simplicity	<p>CGU is faced with groups of stakeholders that need to work on a common and transparent basis, and negotiate towards the choice of a portfolio of audit projects.</p> <p>The suggested module should absorb the methodology developed for the audit projects evaluation and analysis of the generated portfolio results. Additionally, it should allow negotiation between stakeholders who present diverging views.</p> <p>There is a will on the part of the CGU managers to make use of this DSS in order to contribute to the allocative efficiency of the resources available to CGU.</p>
2. Define design objectives	
a) Whether quantitative or qualitative measures are to be used b) Appropriateness of objectives c) Resources required by design objectives	<p>The inputs and outputs must be similar to those used in e-Aud, with the judgments being qualitative inputs (in the multicriteria evaluation of audit projects) and the outputs consisting in numerical quantitative scales.</p> <p>The e-Aud system already supports the decision on the selection of audit projects to be selected for the Operational Plan. What is needed is to graphically display the information on the evaluations of audit projects according to the multicriteria models built and support the negotiation, as necessary.</p>

	<p>The DSS will then require a graphical user interface that can support the negotiation module, not yet implemented in e-Aud. It must be used by decision-makers to input data and decisions, to retrieve data from related databases, and to provide graphical information for the users.</p> <p>The database can be updated during the portfolio selection process through direct user input, interactions with associated project databases, and from the outputs of models and their components.</p> <p>The module must present the estimated identification of expected resources.</p>
3. Artefact design and development	
<p>a) Design and development approach used</p> <p>b) Measures used to determine the innovative features of the system</p>	<p>The DSS module must also have a user-friendly interface, following e-Aud interface standard, which hides the complexities of the system and its models from decision-makers, and provide a bridge between users and other components of the DSS.</p> <p>The innovative features will consist in the ability of making it possible the informed negotiation framework to support CGU managers in the Operation Plan elaboration process, making use of negotiation techniques to support and search for consensus.</p> <p>It should also present the results of model computations to users and allow them to interact with the system to arrive at satisfactory solutions.</p>
4. Identify design context	
a) Determine the context in which the system is to be used and further tested	The system is to be used within an audit context, in which a negotiation process is necessary. It can be tested and applied in resource allocation contexts, where portfolio definition is required and with decision-makers in conflict of interest or diverging views.
5. Measure effectiveness and efficiency	
a) Effectiveness and efficiency of system within its application context	It is expected that by integrating e-Aud and this module, and by all phases of defining, evaluating and negotiating audit projects in a single environment, the effectiveness and/or efficiency of internal processes, and consequently the results of the work performed, will increase.

b) Whether effectiveness and/or efficiency meet target requirements	
6. Communication of results	
a) Determine how the outcomes are to be presented b) Determine whether the communication structure is appropriate for the target audience c) Determine whether the system outputs match discipline knowledge	<p>Outputs should be presented following e-Aud interface standards.</p> <p>The module should allow the perception and the development of the rounds of negotiations, defined according to the informed negotiation framework.</p> <p>The environment must be friendly and adaptable to the different users and CGU departments.</p>

From the above, in line with the concepts of DSS architectures raised in the literature, in Figure 5.10 we present an architectural suggestion for the context of CGU. Our proposal of DSS module should contain the main components of a standard DSS and should be integrated with CGU's corporate systems (e-Aud). In terms of DSS Database, it can make use of CGU's corporate systems databases (CGU-Proj, e-Aud, SEI, ...), which contains information on audit projects, team profiles, and schedule. In terms of DSS Model Management System - mathematical and analytical models - the module should implement the evaluation models of audit projects developed in previous chapters and the instruments/tools developed for negotiation. The DSS user interface should use the graphical interface following standard already adopted in e-Aud. The details of the negotiation module that appear on the right side of Figure 5.10 will be provided in Subsection 5.5.

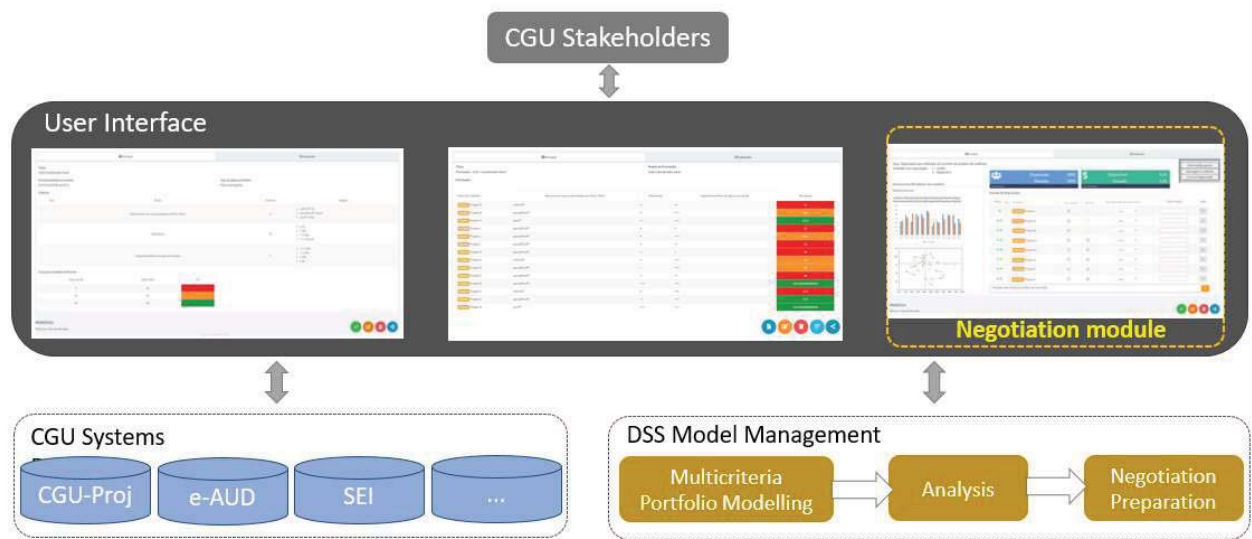


Figure 5.10 – DSS module architecture proposal.

Focusing on the new system e-Aud, we can mention that the system was already designed by the CGU Auditing Issues Innovation Coordination to allow management of resource allocation for audit projects and it is easy to incorporate the final multicriteria structure (which corresponded to the result of our methodology for structuring multicriteria models – applied outside of DSS) for defining and evaluating audit projects , as can be seen in the Figures Figure 5.11 and Figure 5.12 and will be explained in the next section. Comparatively, it is more challenging to include a negotiation component into the system. Thus, a new module that supports the entire negotiation process must be fully developed and should implement the algorithm developed for the informed negotiation framework presented in Chapter 4, as shown in Figure 4.11.

To sum up, within the CGU context, we suggest the following DSS negotiation module features (which enable a set of functionalities):

- Integration between different enterprise systems CGU, allowing all phases of definition of audit projects, evaluation and discussion/negotiation of the portfolios to be made in a single environment;
- Environment friendly and adaptable to the different users, supporting the negotiation techniques they find the most suitable to each context;
- A cooperative DSS that permits the CGU decision-maker to modify, complete, or refine the decision recommendations and information provided by the system about the audit projects and that

presents the different multicriteria instruments to support negotiation and increase effectiveness and efficiency of CGU works.

5.5. Integration with the CGU Corporate System (e-AUD)

Since e-Aud was designed and implemented by a specialized CGU team to replace the previous system (CGUProj) with a new corporate audit system that manages and supports the planning, the execution and the monitoring of audit activities, it is important to clarify and delimit the contributions that emerged from this thesis. The premises that were already set by the specialized CGU team when the system was designed (and should not be attributed to any influence of this thesis) are: auditing as a project; flexible operationalization; unification of systems (CGUProj, SEI, Audit Tracks, etc ...); system adapted to compartmentalized or matrix organizational structures.

Throughout the thesis, we specifically contributed with methods and tools to assist the evaluation of projects based on the multicriteria models built, the analysis of results and the informed negotiation. Using some techniques and methods suggested in the structuring framework (within a range of available techniques and methods) and with the participatory processes designed, it was built multicriteria group models (supported by M-MACBETH). As it is not possible to know *a priori* which techniques and methods will be chosen to be applied in structuring multicriteria models, this structuring phase cannot be integrated with e-Aud but the final multicriteria models generated can. Therefore, the e-Aud has a flexible operationalization and the system is already adapted to implement the type of multicriteria models developed in Chapters 3 and 4 of this thesis. In this way it is possible to evaluate the audit projects according to the different multicriteria models inside e-Aud system that depict distinct stakeholder group perspectives.

The results of applying these models to audit project sets can generate relevant information to support the negotiations needed to define the SFC Operational Plan. What is not yet implemented in e-Aud and requires more thought is the incorporation of the different outputs / graphical instruments defined by the methodology proposed in Chapter 4 to support informed negotiation.

Thus, as shown in Figure 5.11 and Figure 5.12, the audit coordinators' group multicriteria model and the superintends' group multicriteria model (developed in Chapters 3 and 4) can be configured in e-Aud, presenting the values functions for evaluating audit projects (Equations 5.1 and 5.2) according to each model. The system can also be parameterized according to the impact levels (partial value score) of each criterion. The descriptors were presented in Appendix III and summarized in the Table

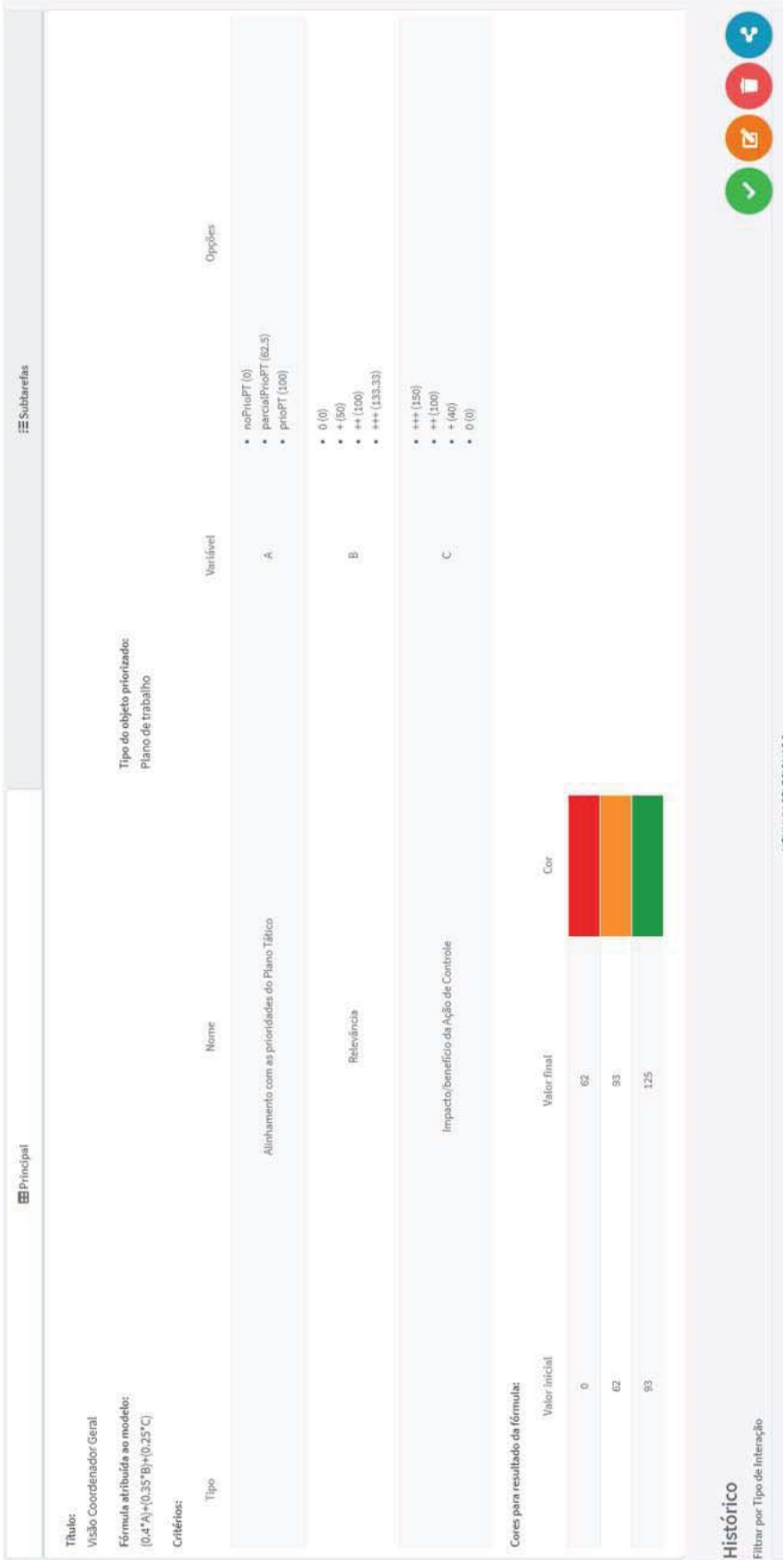
5.3. The same logic can be considered for implementing doability models. It is important to highlight that the design of these models was developed within this PhD study and implemented with the collaboration of the CGU Innovation Coordination team.

$$v_j(A_j, B_j, C_j) = 0,4. A_j + 0,35. B_j + 0,25. C_j \quad (5.1)$$

$$v'_j(A'_j, B'_j, C'_j) = 0,5. A'_j + 0,35. B'_j + 0,15. C'_j \quad (5.2)$$

Table 5.3 – Summary of group model parameters for e-Aud deployment.

Audit coordinators' group model		Superintendents' group model	
Criterion	impact level (partial value score)	Criterion	impact level (partial value score)
Alignment with the Tactical Plan priorities (A)	noPrioPT (0) parcialPrioPT (62,5) prioPT (100)	Criticality (A')	0 (0) +(55) ++(100) +++ (140)
Relevance (B)	0 (0) +(50) ++(100) +++ (133,33)	Relevance (B')	0 (0) +(65) ++(100) +++ (120)
'Impact / Benefit of Control Action (C)	+++ (150) ++(100) +(40) 0(0)	Alignment with the Tactical Plan priorities (C')	noPrioPT(0) parcialPrioPT(60) prioPT (100)



Valores para resultado da fórmula:

Valor inicial

Valor final

Cor

0	62	
62	93	
93	125	

Histórico

Filtrar por Tipo de Interação

✓

✎

🗑

🔄

Figure 5.11 – Prioritization evaluation model in e-Aud according to the view of the audit coordinators group.

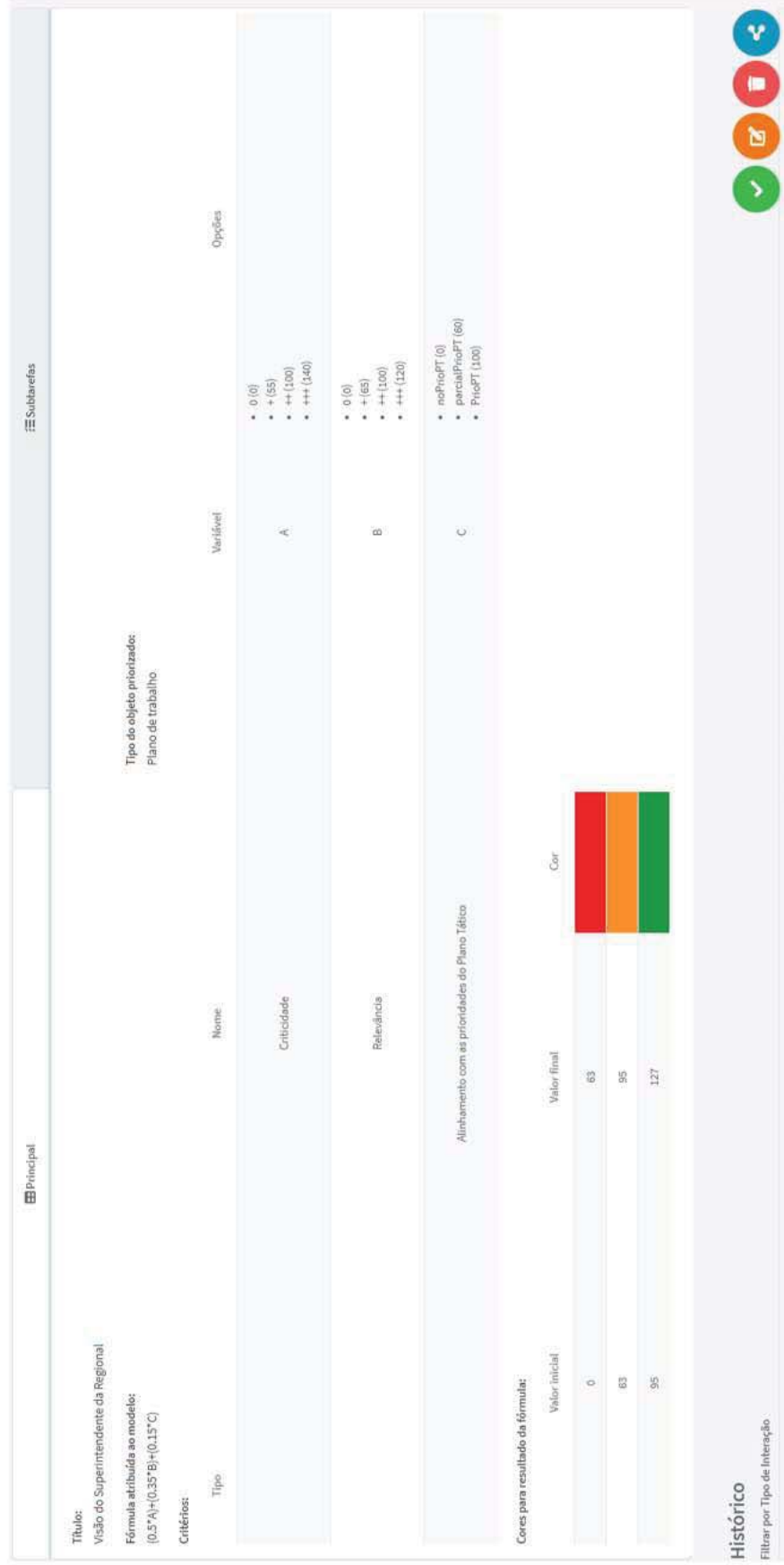


Figure 5.12 – Prioritization evaluation model in e-Aud according to the view of the superintendents group.

Taking the perspective on the three axes needed to implement a DSS module architecture proposal, namely data management, user interface and model management, it is interesting to briefly discuss each of these components that define the new system module proposal.

The last cited axis (model management) has already been commented throughout the section. The e-Aud system was ready to absorb and be configured prioritization models for different groups of models. Testing the methodology developed in this thesis, a set of audit projects will be submitted to the evaluation of both models, in order to obtain the differences of results according to each model. For a hypothetical set of audit projects to be evaluated, Figure 5.13 and Figure 5.14 show the results of these models implemented in e-Aud.

In interviews and discussion meetings that dealt with the implementation of multicriteria models in e-Aud, it was suggested by the CGU Auditing Issues Innovation Coordinator the inclusion of colour scales for model results, based on the result ranges of the value functions. The results that will be generated by the system will be the basis for implementation of graphs to support the negotiation phase. It is also worth mentioning the ease of adjustments and adaptations in the implementation of the models in the e-Aud system, if necessary, which makes the methodology even more attractive to be absorbed and internalized in the CGU.

Note that the presented part still lacks the graphical information and analysis of those outputs, such as the benefit graphs, the doability graphs and the strategic matrix that are key instruments to support the negotiation stage. Nevertheless, these instruments will be included in the list of requirements for e-Aud system enhancement and implementation of the new integrated negotiation module.

In terms of data management, the new negotiation module must be integrated with e-Aud database. Regarding the user interface, it is suggested that the system interface has the components presented in the illustrative template in Figure 5.15, containing the main information about the results of the models, space for messages and information about the portfolios generated throughout the process. We emphasize that this interface should bring graphical information to support informed negotiation, as well as contain space for message exchanges between those involved in the negotiation. As negotiation rounds take place, stakeholders should be able to see the final portfolio being defined during the negotiation, in terms of incoming projects and those being excluded from the final set.

Principal		Subtarefas	
Título: Priorização - 2019 - Coordenador Geral		Modelo de Priorização: Visão Coordenador Geral	
Priorização:			
Plano de Trabalho	Alinhamento com as prioridades do Plano Tático	Relevância	Impacto/benefício da Ação de Controle
2777233 Projeto N	noPrioPT	0	++
4793391 Projeto M	parcialPrioPT	0	+++
4793427 Projeto K	prioPT	++	+++
4793468 Projeto J	parcialPrioPT	0	0
4793461 Projeto L	parcialPrioPT	0	+++
4793492 Projeto I	parcialPrioPT	0	++
4793470 Projeto H	parcialPrioPT	0	+
4793471 Projeto G	noPrioPT	++	+++
4793474 Projeto D	parcialPrioPT	+	+++
4793475 Projeto C	parcialPrioPT	0	++
4793476 Projeto B	parcialPrioPT	+++	+++
4793477 Projeto A	noPrioPT	0	+++
4793478 Projeto X	parcialPrioPT	++	+++
4793479 Projeto W	prioPT	+++	+++
		Resultado	
		25	
		62,5	
		112,5	
		25	
		62,5	
		50	
		35	
		72,5	
		80	
		50	
		109.16550000000001	
		37,5	
		97,5	
		124.16550000000001	

Figure 5.13 – Prioritization evaluation model in e-Aud according to the view of the superintendents group (illustrative sample set).

Principal

Subtarefas

Título:

Priorização - 2019 - Regional

Priorização:

Modelo de Priorização:

Visão do Superintendente da Regional

Plano de Trabalho	Criticidade	Relevância	Alinhamento com as prioridades do Plano Tático	Resultado
#731698 Projeto J	+	0	noPrioPT	27.5
#777121 Projeto N	+	+	parcialPrioPT	59.25
#731687 Projeto K	+++	++	PrioPT	120
#731591 Projeto M	0	++	PrioPT	50
#731699 Projeto I	0	+++	noPrioPT	42
#731693 Projeto L	++	+	noPrioPT	72.75
#731614 Projeto D	++	0	PrioPT	65
#731670 Projeto H	0	+	parcialPrioPT	31.75
#731673 Projeto E	+++	+++	parcialPrioPT	121
#731671 Projeto G	++	0	noPrioPT	50
#731672 Projeto F	+	+++	parcialPrioPT	78.5
#731675 Projeto C	+	+	parcialPrioPT	59.25
#731676 Projeto B	+++	+++	PrioPT	127
#731677 Projeto A	+	0	noPrioPT	27.5



Figure 5.14 – Prioritization evaluation model in e-Aud according to the view of the superintendents group (illustrative sample set).



5.6. Discussion

This study presents a DSS negotiation module architecture proposal to consolidate the concepts used in developing multicriteria resource allocation tools to assist decision-makers in selecting audit projects in a systematic way, in order to facilitate the use of negotiation techniques to support the portfolio selection in the auditing context. As stakeholders may often disagree in such situations, and the DSS should provide support for reaching a consensus, the proposed architecture combines multicriteria methods that are well grounded in theory with those that are easy to understand, and applies them in a logical manner.

Definitions of the DSS module architecture features in terms of management model, data model and user interface model were presented. These features allow a choice of instruments/views by CGU stakeholders to support the negotiation of audit projects portfolio selection through a decision support module system, integrated within the CGU Audit Corporate System. The suggested DSS supports CGU stakeholders in capturing and making explicit their own actual preferences, interacting with them in several steps of decision-making process. The architecture of the DSS module was proposed according to concepts raised from the DSS literature and was technically supported by the CGU Auditing Issues Innovation Coordination development team.

Since in this chapter we present only the architecture of the DSS module to be integrated with the corporate system used in the CGU, more work needs to be done to enable system implementation and approval within the organization. Complementary phases of DSS development and testing have yet to be developed to confirm the applicability of the proposed architecture. Thereby, the receptivity and usability of the suggested module can only be tested and validated after effective implementation.

In terms of study limitations, given that the e-Aud system is also a very recent corporate system within the CGU, which is in the final stages of implementation and deployment, it will still take time to learn and mature until this new corporate system fully meets expectations of audit teams. For this reason, within this research study we try to present at this moment the suggestion of DSS module architecture to be integrated with the e-Aud system and that can take advantage of the knowledge and methodology developed in this thesis.

In any case, there is great potential and openness on the part of members of the CGU Auditing Issues Innovation Coordination to develop and implement the module at CGU. A support system for multicriteria portfolio decisions with the negotiation approach will be useful for the CGU. Additional specifications and new requirements for the DSS should still emerge as the software development

team proceed with the building of the system module. To conclude, one should emphasise that robust systems, developed according to solid concepts and approaches consolidated in the literature, allow organizations like CGU to fulfill its institutional mission in a more efficient, transparent and innovative way.

Chapter 6 CONCLUSION AND FINAL REMARKS

This thesis developed a socio-technical multicriteria approach to support audit organizations in project selection and resource allocation decisions. In this final chapter, we present the overall findings of the study, the main contributions to literature and to the Comptroller General of the Union (CGU), the main limitations of the work, as well as make suggestions for future work.

6.1. Key messages

As discussed at the beginning of this thesis, the CGU in Brazil faces the challenge of, under the presence of scarce resources, executing audit projects across distinct management and public policies themes, involving multidisciplinary teams and stakeholders, with different opinions and views. The work presented in this thesis was inspired by a necessity for improving efficiency in the internal resource allocation processes of an audit organization, and permitted developing a socio-technical multicriteria methodology that combines technical components of multicriteria approach with negotiation tools and techniques for support the selection of audit projects.

Based on the gaps found in the literature, four research questions were elaborated and guided the development of this work. Research question 1, 'How to structure appropriately multicriteria resource allocation models (MRAMs) in the auditing context?', was addressed in Chapter 2, where a literature review was performed and a framework to support structuring MRAMs was proposed. Research question 2, 'How to design a socio-technical process to apply a MRAM structuring framework within an audit context?', was tackled in Chapter 3, in which a socio-technical process to implement the framework proposed in Chapter 1 was adopted and tested in a real-world situation at CGU, with the proposed methods, techniques and tools to structure a model being combined with participatory processes for the case study. Research question 3, 'In the presence of divergent positions or conflicts views, how to define a multicriteria based negotiation process to support different groups of decision-makers in the selection of audit projects?', was addressed in Chapter 4, representing a key contribute of this PhD thesis. In that chapter it was presented a methodology to build MRAMs to assist the evaluation of the audit projects to compose the portfolio of the Comptroller Department of CGU and the allocation of scarce resources, integrated with negotiation tools. Lastly, research question 4, 'How

to design a Decision Support System (DSS), making use of the data available in auditing information systems, to support auditing resource allocation decision-making?', was addressed in Chapter 5, in which it was designed a DSS module architecture containing the main features of the methodology developed by the previous studies, thus allowing improvements in the architecture of existing systems in CGU to enhance multicriteria negotiation.

The adoption of the methods and techniques presented in throughout this study has great potential to bring positive impacts to the decision-making processes of the organization, supporting resource allocation decisions with greater robustness and transparency.

Generically, we have shown how multicriteria resource allocation techniques can be applied in a real auditing context. Negotiation tools can also be used to systematize the confrontation of situations of divergence and conflict, and to search for convergence towards agreement. By combining multicriteria methods with negotiation tools and techniques, it is possible to build multicriteria resource allocation tools in a shape to help informed negotiations supported by corporate systems.

6.2. Main Contribute to Multicriteria Resource Allocation Literature

In this study we saw that multicriteria portfolio analysis concepts and tools coupled with negotiation strategies can be used to inform a transparent and negotiated selection of audit projects; and that there is relevance and scope for developing and testing such type of models to assist the evaluation and negotiation of audit projects to integrate the Operational Plan at CGU. Thus, as a contribution to the literature, we were able to implement and present how to integrate negotiation within Portfolio Decision Analysis (PDA) modelling in an audit context. Specifically, it designed and tested a socio-technical approach, based upon multicriteria resource allocation and negotiation techniques, to support the selection of audit projects.

Throughout the study, we also presented a framework to support the structuring of MRAMs by compiling methods and techniques to support problem identification, stakeholder identification, identification of objectives and values, identification of alternatives, as well as the identification of constraints and uncertainties. The framework steps allow to frame the problem and to generate the information needed to build a MRAM; and the application of the framework requires thinking about which decision-makers and stakeholders should be directly involved in each framework step and under which participatory format. It was noteworthy that there are various techniques available in the

literature to address each of these steps, but up to our knowledge these techniques have not been presented in an integrated form.

It was also presented the design and application of a socio-technical process for building MRAMs within the real context of an audit organization. The model considered both the evaluation of project impacts and doability (as a proxy to costs) of audit projects. The results of the structuring framework application in the CGU case showed that there was a need to develop tools to inform the allocation of limited resources to audit projects, and that their use with proper participatory methods for stakeholders involvement was key. Therefore, in the CGU case, the application of the framework has shown the presence of groups of decision-makers with different perceptions about how to evaluate the audit projects, and lead to the development of models for each group so as to capture their views, before proceeding to further discussion and negotiation.

By combining multicriteria modelling with negotiation tools and techniques within a constructive process, departing from the decision problem faced by CGU stakeholders and by modelling their preferences, it was possible to effectively perform an informed negotiation framework. Negotiation tools were used to systematize the confrontation of situations of divergence and conflict, and to search for convergence. Thus, this study has made a contribute by integrating negotiation techniques with PDA modelling within an audit context.

Furthermore, it was designed a DSS module containing the main features of the methodology developed by the previous studies, thus allowing for improving existing corporate systems in CGU to enhance multicriteria negotiation. The adoption of this module has the potential to provide interactive and flexible mechanisms/instruments for CGU stakeholders making decisions concerning auditing projects, as well as to analyse relevant data, to generate portfolios, and to make choices of the type of audit projects.

6.3. Main Contribute to CGU

Looking deeper into the application of the methodology in an audit organization context and taking the perspective of the experience evidenced by CGU throughout this study, we observe that the study presented in this thesis has had an impact on CGU internal processes.

Firstly, the Comptroller Department of CGU (*Secretaria Federal de Controle Interno – SFC* in Portuguese) is the CGU department responsible for defining which audit projects should be carried out by the teams, materialized in the Operational Plan. Previously, audit coordinators and superintendents

chose audit projects that would compose the Operational Plan on an *ad hoc* basis and submitted those projects for approval of the SFC board of directors. Thus, at the beginning of this thesis, there was not a structured, transparent and systematic evaluation at CGU of the evaluate the benefits, risks and costs of audit projects.

Throughout the studies presented, we were able to deliver to CGU a methodology based in the PDA and negotiation literature to support the selection of audit projects. The developed methodology aimed at enhancing multicriteria resource allocation decisions in an auditing context, and integrated negotiation tools. Hence, supported by an informed negotiation framework, CGU can now deal with groups of stakeholders that are able to work on a common and transparent basis, and negotiate towards the choice of a portfolio of audit projects, to reach a compromise solution on the project portfolio.

Secondly, work has also been done to improve CGU's corporate systems to support the methodology developed. CGU makes use of corporate systems to support the planning and execution of its activities and to store the relevant data relating to its audit projects, and these systems have been influenced by the work developed in this thesis. In fact, a new audit system is currently being implemented in the organization and it incorporate some results from the developed research; and a novel DSS module architecture was designed, to be integrated into the CGU's new corporate system, enhancing multicriteria negotiation and providing interactive and flexible support for CGU stakeholders making choices about audit projects portfolios. It is important to mention that there is an intention on the part of CGU board of directors in using this new DSS module suggested.

It is also important to highlight the fundamental role of the participatory methods adopted throughout this thesis. In practice, participation processes were designed and key to achieving the results and the internalization of the approach within CGU. The developed approaches and models incorporated the perspectives and views of CGU stakeholders. Positive feedback has also been recorded about the applicability of the methodology in the context of CGU. Participants believe that the developed methodology has the potential to improve CGU's decision-making processes and the participatory sessions were enriching for the knowledge and appropriation of the developed methodology. The test about the negotiation process was supported by information and data, and enabled all involved parties to reach a compromise decision in a friendly format.

Finally, one must also emphasize the commitment of CGU's top management that has grown along the development of this thesis. From the directors and chiefs to the secretariat to the executive-secretary (which in CGU are the second level in the ministry's chain of command), a large number of

individual supported the development of this research, helped in implementing methods, as well as shows evidence of the internalization at CGU of the knowledge developed throughout this thesis.

Through the use of specifically designed participatory process, we were able to experience a decrease in the distance between the scientific community and CGU, and within this process, CGU stakeholders identified themselves with the whole process, making it easier to implement and deliver the research. Furthermore, acceptability of the proposed methods was seen as natural. Thus, specifically for the CGU context, this thesis shows the contribute and usefulness of MRAMs to improve auditing decisions.

6.4. Main Contribute to Auditing Literature

One of the major challenges faced by public and private organizations that perform audits is how to plan the allocation of resources to their activities. Since resources are scarce and the requests for audit work are high, it is recognised as important within those organizations to put some thinking on how to allocate resources efficiently to auditing projects.

The methods developed in this thesis support the planning of audit work through systematic processes. Following the methodology, it is possible to make an auditing organization reflect and consider in a structured and systematic process which objectives are to be attained, which audit projects should be performed by the teams, and which resources are to be allocated, while accounting for stakeholders' views.

Multicriteria approaches have been shown to be useful to evaluate audit projects and to support resource allocation decisions in auditing, even when there we have divergences of opinion and the use of negotiation is needed to arrive at a compromise solution. Furthermore, up to our knowledge MRAMs have not been reported for the auditing context by literature in the area, with this thesis making a contribute to auditing literature.

6.5. Limitations

Regarding the limitations observed during the development of the work, it should be emphasized that the methods presented in the structuring framework were not exhaustively explored individually and some possible difficulties may be faced when they are actually applied in other

contexts different from those presented in this thesis. It is also important to mention that our search protocols used in literature reviews throughout the work may not have been specific enough and could have limited the search results so that some relevant techniques (useful to our work) may not have been captured.

Another limitation to be mentioned is related to the need to adapt the models and revisit the steps of the structuring framework every time the application context is changed. The methodology developed is specific to each situation and cannot be applied to other contexts without proper adaptation. At CGU, for example, we have resource allocation decisions involving other secretariats (other than the SFC), who dispute the scarce resources to carry out their projects. However, new models need to be built to support these decision-makers. Thus, given the constructivist epistemology chosen for this study, the adaptation of the methodology before its application to other contexts may be time-consuming.

6.6. Future Research

Future research can be focused on using the development approach in unexplored areas of application, as for instance by other non-audit-oriented public organizations that carry out activities through projects and need to make resource allocation decisions.

Additional work can also be done to explore the methodology presented and to test the processes developed in other CGU departments by testing the approach with other stakeholders. Extrapolating what has already been developed for the SFC, challenges faced by other CGU finalistic departments such as Secretariat of Transparency and Prevention of Corruption, Federal Ombudsman's Office, Corrections Internal Affairs Office and Anti-Corruption Secretariat, can be explored within the methodology as they compete with the overall CGU budget.

Other multicriteria and negotiation techniques and tools not mentioned in this study can also be tested and incorporated into the methodology to enrich the processes presented with new technologies. The same is true for exploring other untapped social processes. In this sense, the web questionnaire applied in this thesis (Appendix II) could be adapted and constructed based on the Likert scale to facilitate the analysis and consolidation of the answers. Delphi process can also be developed and applied in the context explored in this study.

Further studies need to be done to develop integrated software to support the construction of MRAMs with negotiation. Also, there is space for exploring other participatory approaches.

Finally, integrating the methodology developed with the risk management knowledge area also represents a rich path to be explored. For the audit literature, studies related to planning and scheduling can also be explored to be incorporated in the context of this study.

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Appendix I

Appendix I presents (in Portuguese) semi structured interview plan to gather information on the tactical and operational plan.

Desenvolvimento do Plano Tático da SFC

Main Questions	Additional questions	Clarifying questions
<ul style="list-style-type: none"> Poderia me descrever de forma sucinta o processo atual de desenvolvimento do plano tático da SFC? <p>OR</p> <ul style="list-style-type: none"> Como é elaborado o Plano Tático da SFC? 	<ul style="list-style-type: none"> Quais são os principais objetivos do plano? Como é feita a priorização de temas? Como são definidos os vínculos entre os temas priorizados e as ações de controle a serem executadas para auditá-los? Quais são as ligações entre as ações de controle e os objetivos estratégicos? Como são medidos os custos das ações de controle? Que recursos são necessários? Como são medidos os benefícios das ações de controle? Existem incertezas envolvidas nestas medições? Como são mapeadas essas incertezas? Existem fatores externos que podem prejudicar o processo de elaboração do plano? Quais? Quais as principais dificuldades enfrentadas no processo atual de elaboração do plano tático? 	<ul style="list-style-type: none"> Can you expand a little on this? Can you tell me anything else? Can you give me some examples?

<ul style="list-style-type: none"> Quem são as pessoas envolvidas no processo de elaboração? <p>OR</p> <ul style="list-style-type: none"> Poderia me listar os principais participantes do processo? 	<ul style="list-style-type: none"> Como é definida a participação dos envolvidos no processo? Quais são os papéis de cada um desses participantes? Quais são os níveis de poder de decisão de cada um desses envolvidos no processo de elaboração? Quais são as contribuições de cada um desses participantes? 	
Conclusion of interview		
<ul style="list-style-type: none"> O plano tático atual tem atendido as expectativas? <p>OR</p> <ul style="list-style-type: none"> O formato do plano está adequado? 	<ul style="list-style-type: none"> Há algo a respeito da elaboração do plano tático da SFC que gostaria de acrescentar? <p>OR</p> <ul style="list-style-type: none"> Há algum outro tópico relacionado que gostaria de mencionar? 	

Desenvolvimento do Plano Operacional da SFC

Main Questions	Additional questions	Clarifying questions
<ul style="list-style-type: none"> Poderia me descrever de forma sucinta o processo atual de desenvolvimento do plano operacional da SFC? <p>OR</p> <ul style="list-style-type: none"> Como é elaborado o Plano Operacional da SFC? 	<ul style="list-style-type: none"> Quais são os principais objetivos do plano? Como é feita a proposição de projetos? Como são definidos os vínculos entre os temas priorizados e as ações de controle a serem executadas para auditá-los? Quais são as ligações entre as ações de controle e os objetivos estratégicos? Como são medidos os custos das ações de controle? Que recursos são necessários? 	<ul style="list-style-type: none"> Poderia expandir um pouco mais essa ideia? Há mais alguma coisa a acrescentar sobre isso? Poderia me dar alguns exemplos?

	<ul style="list-style-type: none"> • Como são medidos os benefícios das ações de controle? Existem incertezas envolvidas nestas medições? • Como são mapeadas essas incertezas? • Existem fatores externos que podem prejudicar o processo de elaboração do plano? Quais? • Quais as principais dificuldades enfrentadas no processo atual de elaboração do plano tático? 	
<ul style="list-style-type: none"> • Quem são as pessoas envolvidas no processo de elaboração? <p>OR</p> <ul style="list-style-type: none"> • Poderia me listar os principais participantes do processo? 	<ul style="list-style-type: none"> • Como é definida a participação dos envolvidos no processo? • Quais são os papéis de cada um desses participantes? • Quais são os níveis de poder de decisão de cada um desses envolvidos no processo de elaboração? • Quais são as contribuições de cada um desses participantes? 	
Conclusion of interview		
<ul style="list-style-type: none"> • O plano operacional atual tem atendido as expectativas? <p>OR</p> <ul style="list-style-type: none"> • O formato do plano está adequado? 	<ul style="list-style-type: none"> • Há algo a respeito da elaboração do plano operacional da SFC que gostaria de acrescentar? <p>OR</p> <ul style="list-style-type: none"> • Há algum outro tópico relacionado que gostaria de mencionar? 	

Appendix II

Appendix II presents (in Portuguese) the full questionnaire applied, through the Google Docs platform, in the period from 04/05 to 05/31/17, with a target audience of 200 stakeholders (directors, audit coordinators, team leaders, superintendents). As a result, 72 responses were collected, corresponding to a result with 95% confidence level and 9% of error margin. The responses were consolidated after the questionnaire.

Questionário

Este questionário leva em torno de 10 minutos para ser respondido! Possui como público-alvo, todos os Coordenadores-Gerais de Auditoria, Superintendentes e seus respectivos Chefes de Divisão/NAC.

Faz parte de um trabalho acadêmico que está sendo desenvolvido pela AFFC **Vivian Vivas**, sob a supervisão da Profª Drª Mónica Duarte Oliveira, no âmbito do Programa de Doutorado em Engenharia e Gestão no Instituto Superior Técnico da Universidade de Lisboa.

O referido estudo tem como objetivo o desenvolvimento de metodologias de apoio aos processos decisórios de alocação de recursos da CGU na execução de suas ações de controle. Para tal efeito, num primeiro momento, foi desenvolvido um framework para auxiliar a estruturação de modelos de afetação de recursos e sua aplicação será testada, em associação com a DC, no **processo de elaboração do Plano Operacional da SFC**.

Sua participação é muito importante e as contribuições apresentadas poderão refletir em melhorias nos processos decisórios de alocação dos recursos financeiros, humanos e logísticos da CGU.

Como responder ao questionário?

O questionário deve ser respondido individualmente, tendo como foco o processo de elaboração do Plano Operacional da **sua** Coordenação-Geral/Superintendência, selecione as opções que mais se adequem a sua realidade, marcando mais de uma opção quando conveniente e complementando por escrito quando não encontrar a opção mais adequada.

1ª Parte. Identificação dos Objetivos do Plano Operacional:

1. Do seu ponto de vista, quais os **principais objetivos** do Plano Operacional (PO)? (máx. 3 opções)

- ☐ Listar as ações de controle (projetos) a serem executadas pela unidade no período.
- ☐ Firmar compromisso com os produtos a serem entregues no período.
- ☐ Organizar os projetos a serem executados de acordo com as prioridades definidas pelo Plano Tático.
- ☐ Dirigir a alocação dos recursos humanos disponíveis na unidade dentro dos projetos.
- ☐ Apoiar o planejamento e consolidação dos trabalhos que envolvam mais de um executor.
- ☐ Ter visão geral das políticas públicas da minha área de atuação/região.
- ☐ Viabilizar o atingimento dos objetivos estratégicos da CGU.
- ☐ Outro(s). Especificar: _____

2ª Parte. Caracterização da escolha dos projetos:

2. Quais os **principais fatores** que devem ser levados em consideração ao se definir qual projeto será proposto no PO, considerando os objetos auditáveis mapeados (máx. 4 opções)?

- ☐ Prioridades institucionais definidas pelo Plano Tático.
- ☐ Capacidade Operacional.
- ☐ Benefícios esperados com a execução do projeto.
- ☐ Materialidade relacionada ao objeto auditável.
- ☐ Competências necessárias para a realização do projeto.
- ☐ Relevância (Estratégia de Governo, Prioridade do Gestor, Veiculação na mídia, Demanda de Órgãos de Defesa).

- ☐ Criticidade (Denúncias, Atuação da CGU, Despesa Sigilosa, Resultados de trabalhos anteriores).
- ☐ Dilema de curto x médio prazo para os benefícios esperados.
- ☐ Expectativa dos resultados advindos da atuação da AI para a sociedade.
- ☐ Potencial de transversalidade da atuação em outras áreas.
- ☐ Outro(s). Especificar: _____

2.1 Tendo em consideração o que é relevante para distinguir os projetos a serem incluídos ou excluídos do PO, ordene os fatores escolhidos na questão anterior, do mais determinante para o menos:

3. Em relação ao seu universo de projetos executados ao longo de um ciclo de plano operacional, em quais linhas de atuação estão concentrados os trabalhos que consomem a maior parte da sua capacidade operacional (máx. 5 opções)?

- ☐ Auditoria Anual de Contas
- ☐ Relatório de Gestão Fiscal
- ☐ Prestação de Contas da Presidência da República
- ☐ Fiscalização em entes Federativos
- ☐ Avaliação da Execução de Programas de Governo
- ☐ Avaliação dos Resultados da Gestão
- ☐ Auditoria sobre Integridade de Estatais
- ☐ Auditoria por Área de Gestão
- ☐ Auditoria em Contratos de Recursos Externos
- ☐ Apuração de Representações e Demandas Sociais
- ☐ Programa Capacita
- ☐ Análise de Atos de Pessoal
- ☐ Avaliação do Planejamento das Auditorias Internas – PAINT
- ☐ Avaliação do Plano de Providências Permanente
- ☐ Análise de Trilhas de Pessoal
- ☐ Análise de Tomadas de Contas Especial
- ☐ Outros Projetos. Especificar: _____
- ☐ Outras Atividades. Especificar: _____

3ª Parte. Identificação de fatores limitativos:

4. Atualmente, como você mede/gerencia a sua capacidade operacional para execução das ações de controle (projetos)?

- ☐ HH (pessoas disponíveis X carga horária).
- ☐ Produtividade (considerando rendimento de cada servidor).
- ☐ Resultado (produtos entregues).

☐ Não possuo indicadores estruturados para medir minha capacidade operacional e, portanto, não realizo essa medição.

☐ Outro(s). Especificar: _____

4.1 Se você mede, qual o valor estimado da sua capacidade operacional anual, de acordo com a unidade de medição assinalada na questão anterior?

5. Considerando que todos os projetos a serem incluídos no PO concorrem a uma quantidade limitada de recursos (humanos, logísticos, financeiros), quais as **principais incertezas** envolvidas nas escolhas dos projetos a serem propostos enfrentadas pela **sua unidade**, quando do processo de elaboração do PO (máx. 3 opções)?

☐ Mensuração dos benefícios/retornos esperados.

☐ Mensuração da demanda de custos envolvidos em cada projeto, seja em termos de esforço de trabalho (HH) ou outros recursos (logísticos, especialistas, ...).

☐ Vinculação do projeto aos objetivos/valores estratégicos a serem alcançados, de acordo com as iniciativas elencadas no Plano Tático.

☐ Disponibilidade da competência necessária na equipe para a execução do projeto.

☐ Surgimento de demandas extraordinárias.

☐ Outra(s). Especificar: _____

6. Considerando o processo atual de elaboração do PO, quais os principais fatores limitativos que alcançam a sua unidade, ou seja, quais as **principais restrições** enfrentadas pela **sua unidade** (máx. 3 opções)?

☐ Prioridades institucionais definidas pelo Plano Tático (entregas obrigatórias).

☐ Disponibilidade operacional de terceiros em projetos que envolvam/dependam de várias unidades.

☐ Capacidade Operacional da unidade (desconsiderando apoio de terceiros).

☐ Disponibilidade da competência necessária na equipe para a execução do projeto

☐ Interdependências entre projetos.

☐ Outra(s). Especificar: _____

7. Há algum tipo de sinergia e/ou interdependência entre os projetos que são propostos para compor o PO da sua unidade?

- ☐ Projetos que devam ser executados simultaneamente
- ☐ Projetos que dependam de outros serem finalizados para iniciarem
- ☐ Projetos mutuamente excludentes
- ☐ Outros. Especificar: _____
- _____

4ª Parte. Avaliação do processo de elaboração do Plano Operacional:

8. Na sua opinião, quais são os **pontos fortes** e os **pontos fracos** do processo atual de elaboração do Plano Operacional da SFC? Havendo oportunidade, o que você consideraria prioritário alterar?

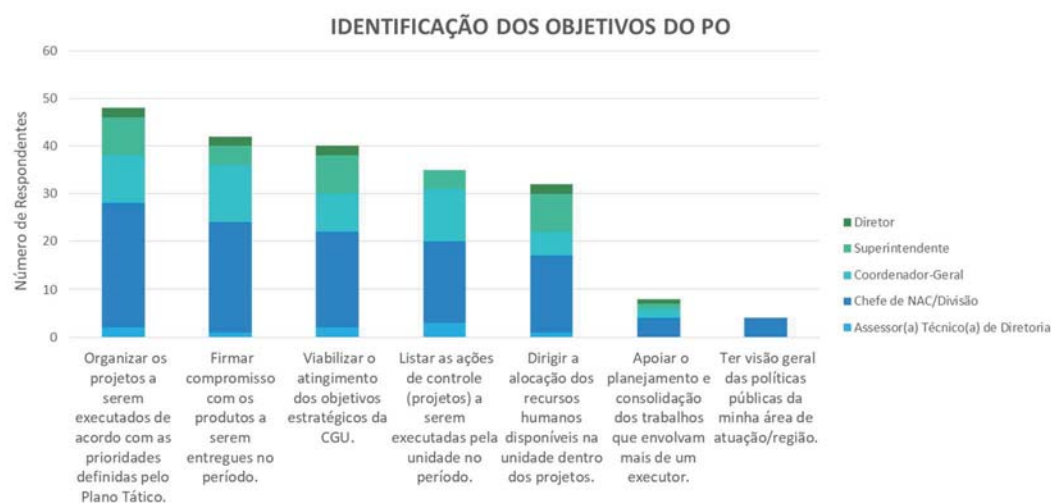
Muito obrigado pela sua colaboração!

Respostas Consolidadas

PERGUNTA 1. Do seu ponto de vista, quais devem ser os PRINCIPAIS OBJETIVOS do Plano Operacional (PO)? (máx. 3 opções)

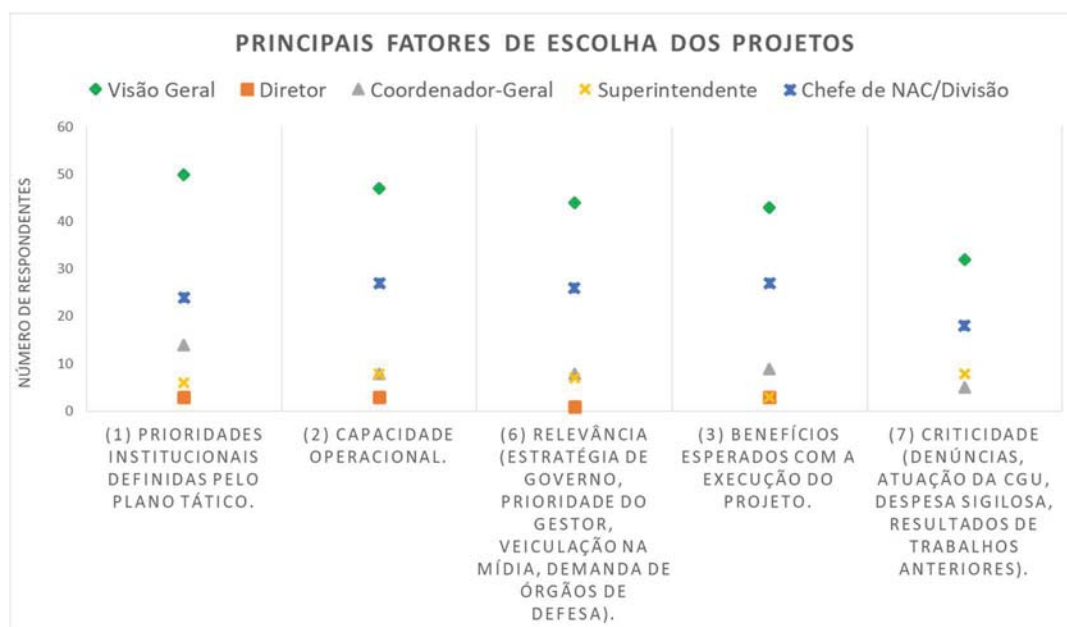
1. Principais objetivos do PO	Assessor (a) Técnico(a)	Chefe de NAC/ Divisão	Coordenador-Geral	Superintendente	Diretor	Total Geral
Organizar os projetos a serem executados de acordo com as prioridades definidas pelo Plano Tático.	2	26	10	8	2	4
Firmar compromisso com os produtos a serem entregues no período.	1	23	12	4	2	4
Viabilizar o atingimento dos objetivos estratégicos da CGU.	2	20	8	8	2	4
Listar as ações de controle (projetos) a serem executadas pela unidade no período.	3	17	11	4		3
Dirigir a alocação dos recursos humanos disponíveis na unidade dentro dos projetos.	1	16	5	8	2	5

Apoiar o planejamento e consolidação dos trabalhos que envolvam mais de um executor.	4	2	1	1	8	
Ter visão geral das políticas públicas da minha área de atuação/região.	4				4	
Total Geral	9	11	48	33	9	09



PERGUNTA 2. Quais os PRINCIPAIS FATORES que devem ser levados em consideração ao se definir qual projeto será proposto no PO, considerando os objetos auditáveis mapeados (máx. 4 opções)?

2. Principais FATORES de escolha de projeto	Asses sor(a) Técnico(a)	C hefe de NAC/ Divisão	Coorde nador-Geral	Dir etor	Sup erin-tendente	T otal Geral
(1) Prioridades institucionais definidas pelo Plano Tático.	3	4	14	3	6	5
(2) Capacidade Operacional.	1	7	8	3	8	4
(3) Benefícios esperados com a execução do projeto.	1	7	9	3	3	4
(4) Materialidade relacionada ao objeto auditável.	1	8	5		4	1
(5) Competências necessárias para a realização do projeto.	1	9	5		1	1
(6) Relevância (Estratégia de Governo, Prioridade do Gestor, Veiculação na mídia, Demanda de Órgãos de Defesa).	2	6	9	1	7	4
(7) Criticidade (Denúncias, Atuação da CGU, Despesa Sigilosa, Resultados de trabalhos anteriores).	1	8	6		8	3
(9) Expectativa dos resultados advindos da atuação da AI para a sociedade.	1	9	5	1	1	1
(10) Potencial de transversalidade da atuação em outras áreas.		1		1		2
(11) Avaliação de Risco.		1				1
Total Geral	11	50	61	12	38	72

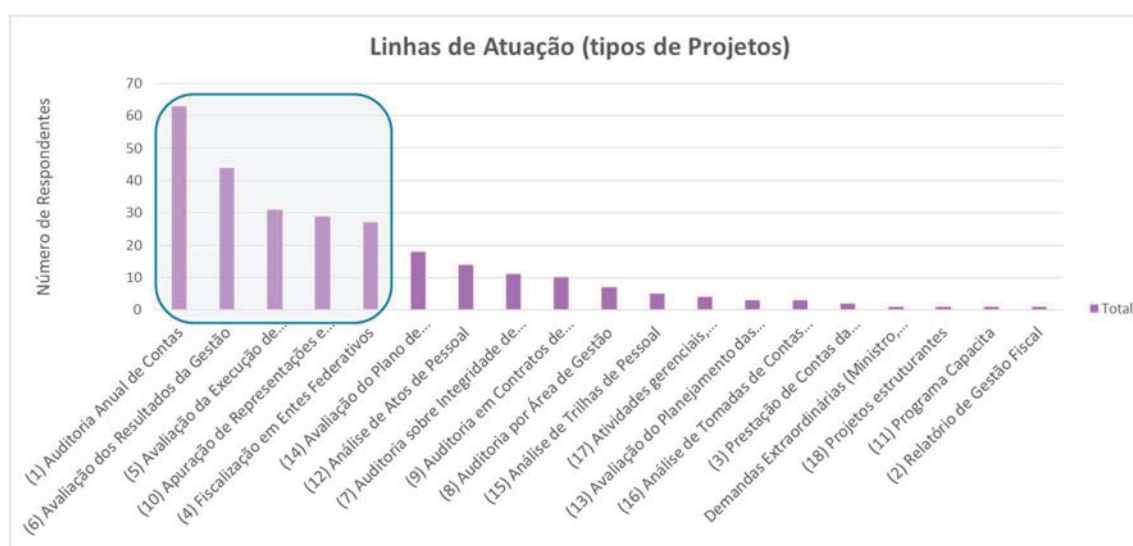


PERGUNTA 3. Em relação ao seu universo de projetos executados ao longo de um ciclo de plano operacional, em quais linhas de atuação estão concentrados os trabalhos que consomem a maior parte da sua capacidade operacional (máx. 5 opções)?

3. Identificação das linhas de atuação	Contagem Geral
(1) Auditoria Anual de Contas	63
(2) Relatório de Gestão Fiscal	1
(3) Prestação de Contas da Presidência da República	2
(4) Fiscalização em Entes Federativos	27
(5) Avaliação da Execução de Programas de Governo	31
(6) Avaliação dos Resultados da Gestão	44

(7) Auditoria sobre Integridade de Estatais	11
(8) Auditoria por Área de Gestão	7
(9) Auditoria em Contratos de Recursos Externos	10
(10) Apuração de Representações e Demandas Sociais	29
(11) Programa Capacita	1
(12) Análise de Atos de Pessoal	14
(13) Avaliação do Planejamento das Auditorias Internas – PAINT	3
(14) Avaliação do Plano de Providências Permanente	18
(15) Análise de Trilhas de Pessoal	5
(16) Análise de Tomadas de Contas Especial	3
(17) Atividades gerenciais, administrativas e de apoio a outras unidades.	4
(18) Projetos estruturantes	1
Demandas Extraordinárias (Ministro, Secretário, Diretor)	1

Total Geral	275
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PERGUNTA 4. Atualmente, como você mede/gerencia a sua capacidade operacional para execução das ações de controle (projetos)?

4. Medição/gerenciamento da capacidade operacional	Contagem Geral
Resultado (produtos entregues)	25
HH (pessoas disponíveis X carga horária)	13
Produtividade (considerando rendimento de cada servidor)	12
Não possuo indicadores estruturados para medir minha capacidade operacional e, portanto, não realizo essa medição	10
Resultado (produtos entregues) e/ou HH (pessoas disponíveis X carga horária)	4
Resultado (produtos entregues) e/ou Produtividade (considerando rendimento de cada servidor)	4
Resultado (produtos entregues) e/ou Produtividade (considerando rendimento de cada servidor) e/ou HH (pessoas disponíveis X carga horária)	2

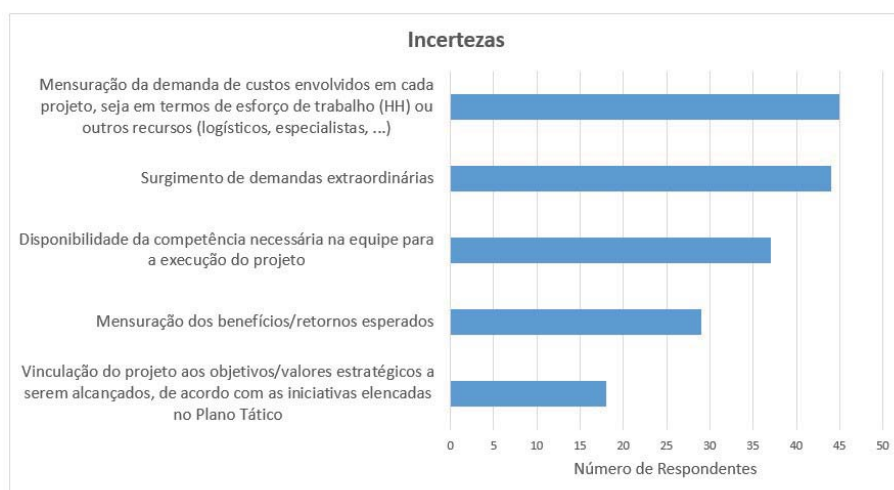
Produtividade (considerando rendimento de cada servidor) e/ou HH (pessoas disponíveis X carga horária)

1

Total Geral	71
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PERGUNTA 5. Considerando que todos os projetos a serem incluídos no PO concorrem a uma quantidade limitada de recursos (humanos, logísticos, financeiros), quais as PRINCIPAIS INCERTEZAS envolvidas nas escolhas dos projetos a serem propostos enfrentadas pela sua unidade, quando do processo de elaboração do PO (máx. 3 opções)?

5. Principais INCERTEZAS envolvidas nas escolhas dos projetos	Contagem Geral
Disponibilidade da competência necessária na equipe para a execução do projeto	37
Mensuração da demanda de custos envolvidos em cada projeto, seja em termos de esforço de trabalho (HH) ou outros recursos (logísticos, especialistas, ...)	45
Mensuração dos benefícios/retornos esperados	29
Surgimento de demandas extraordinárias	44
Vinculação do projeto aos objetivos/valores estratégicos a serem alcançados, de acordo com as iniciativas elencadas no Plano Tático	18
Total Geral	173

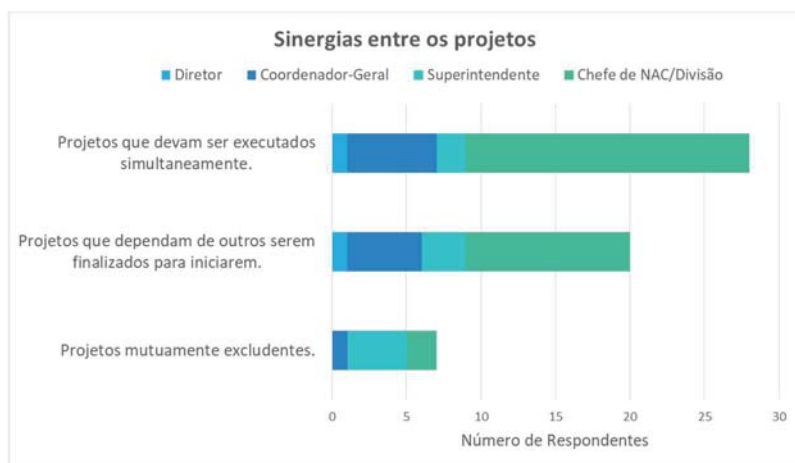


PERGUNTA 6. Considerando o processo atual de elaboração do PO, quais os principais fatores limitativos que alcançam a sua unidade, ou seja, quais as PRINCIPAIS RESTRIÇÕES enfrentadas pela SUA UNIDADE (máx. 3 opções)?

6. Principais RESTRIÇÕES	Contagem Geral
Capacidade Operacional da unidade (desconsiderando apoio de terceiros).	57
Disponibilidade da competência necessária na equipe para a execução do projeto.	41
Prioridades institucionais definidas pelo Plano Tático (entregas obrigatórias).	25
Disponibilidade operacional de terceiros em projetos que envolvam/dependam de várias unidades.	13
Interdependências entre projetos.	6

Uso da cultura de gerenciamento de projetos.	1
Falta de recursos orçamentários.	1
Excessiva carga de trabalho relacionada a demandas extraordinárias, burocráticas, administrativas e de apoio às Regionais.	1
Total Geral	145

PERGUNTA 7. Há algum tipo de sinergia e/ou interdependência entre os projetos que são propostos para compor o PO da sua unidade?



Appendix III

- Qualitative descriptor 'Alignment with the Tactical Plan priorities' of the audit project:

Impact Level	Description: In terms of contributing to the alignment of the audit projects to be implemented with the Tactical Plan (PT) priorities, the audit project ...
prioPT	is related to priority theme in the Tactical Plan
parcialPrioPT	is related to a theme mapped as relevant but not elected as a priority in the Tactical Plan
noPrioPT	is not related to priority theme in the Tactical Plan

- Qualitative descriptor 'Relevance' of the audit project:

Impact Level	Description: In terms of the relevance of the audit project, ie 'whether it is a government strategy, expected economic or social impact and media repercussions', the execution of the audit project ...
+++	presents links to all relevant aspects (government strategy, economic / social impact, media repercussion);
++	presents links to at least three aspects considered relevant and not to all (government strategy, economic / social impact, media repercussion);
+	is linked to one or two aspects considered critical and not all (government strategy, economic / social impact, media repercussion);
0	is not linked to any of the aspects considered relevant.

- Qualitative descriptor 'Impact / Benefit of Control Action' of audit project:

Impact Level	Description: In terms of potential to produce relevant results, changing the reality of public policies and management of audited units, the execution of the audit project ...
+++	presents direct contribution to improving the management and outcomes of public policies;
++	presents direct contribution to the improvement of management or outcomes of public policies;
+	presents slight contribution to improving the management and outcomes of public policies;
0	presents no improvement in public management and public policy outcomes.

- Qualitative descriptor 'Criticity' of the audit project:

Impact Level	Description: In terms of the criticity of the audit project, ie 'if there are associated complaints, if there has been recent CGU performance and the results of the work, if there are demands from defence agencies, if there is materiality', the execution of the audit ...
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+++	is linked to all aspects considered critical (associated complaints, CGU action, defence agency demands and materiality);
++	is linked to at least three aspects considered critical and not all (associated complaints, CGU action, defence agencies demand and materiality);
+	is linked to one or two aspects considered critical and not to all (associated complaints, CGU action, defence agencies demand and materiality);
0	is not linked to any of the aspects considered critical.
