

# Improving Decision Making at Governmental Institutions Through Decision Mining for Professionals

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## Abstract

Governmental institutions translate laws and regulations into decision-related services for many citizens. With this there is great potential for positively contributing to public value via decision making; at the same time anecdotal evidence shows that decision making may easily violate public value as well. While decision making is partly secured by rule-based procedures professionals have to follow, and partly by information systems, decision mining is a new technique which could, when properly applied, improve the quality of decision making for public value. In this PhD-project, the candidate researches how professionals in governmental institutions can best leverage decision mining aiming to answer the following research question: How can professionals in governmental institutions be supported by decision mining techniques in order to improve decision making for public value?

## Keywords

Decision-making, Decision mining, Governmental institutions.

## 1. Introduction

Decisions at governmental institutions are often made in fast-changing, sometimes unexpected, situations [1]. Such a context requires proper support of the decision makers and supplying them with suitable necessary data, procedures, and information systems. If an organization, like the Dutch Tax and Customs Administration, is not consistent in their decision making or has improper support for this, risks are taken that could result in not adhering to values [2]–[4]. So called Decision Support Systems (DSS) support professionals in a decision making process, providing data, workflow and particular information systems support [5], [6]. Utilizing and improving the DSS would inherently improve the quality of decision making [5], [6]. In that respect, leveraging more insight from (historical) data seems promising; through so-called decision mining. A definition of decision mining is: “*the method of extracting and analyzing decision logs with the aim to extract information from such decision logs for the creation of business rules, to check compliance to business rules and regulations, and to present performance information*” [7]. Due to the broad spectrum of the decision making field our research is focused on structured data and utilizes data related to decisions which are already captured by information systems and stored in databases. Consequently, our main research question is: How can professionals in governmental institutions be supported by decision mining techniques in order to improve decision making for public value?

## 2. Background

High-volume operational decisions play a crucial role in the success of organizations and the satisfaction of their customers [8]. These decisions generate a significant amount of data, which can be harnessed to create and make more intelligent decisions [9], [10]. Moreover, operational decisions have the potential to impact individuals' day-to-day lives positively or negatively. For instance, a

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government's decision to grant someone a resident permit can greatly affect the well-being of that person. Similarly, in a hospital setting, an incorrectly executed operational decision can directly influence a person's quality of life. This PhD project focusses on the governmental domain. More specifically, the executive agencies within the government, such as the Dutch Tax and Customs Administration. These organizations execute laws and regulations through the use of business rules. These business rules are in turn used for supporting operational decisions.

To understand the concept of operational decisions, it is important to define them as *"the act of determining an output value from a number of input values, using decision logic defining how the output is determined from the inputs"* [11]. The decision logic, an integral part of the decision-making process, encompasses business rules, decision tables, or executable analytic models that facilitate individual business decisions [11]. Separating and managing these components, such as business rules and decision tables, from other software and processes can provide potential benefits, as previously highlighted by [12], [13]. Given the impact of decisions, the separate management of decision logic becomes even more crucial.

However, there are instances where organizations might not have explicit decision management in place. This could be due to various reasons. Firstly, an organization may be aware of the existence of a particular decision but chooses not to model it explicitly for example due to its integration in existing business processes and thereby not completely following the Separation of Concerns principle [12]. Secondly, an organization might be unaware of certain decisions (due to the vast number of decisions made in an organization), which makes it impossible to model them effectively.

The combination of (business) data analytics with decision management solutions is a common practice [8]. The data recorded from past decisions can be utilized to create smarter decisions in the future [9], [10]. Collecting and analyzing relevant data related to these decisions can provide added value in the design, implementation, and execution of such decisions [14]. Therefore, we include three types of decision mining activities (as shown in Figure 1): 1) the discovery of decisions from decision logs (an event log regarding decisions), 2) checking for conformance of decisions using decision logs and models, and 3) the improvement of decisions through decision logs and models.

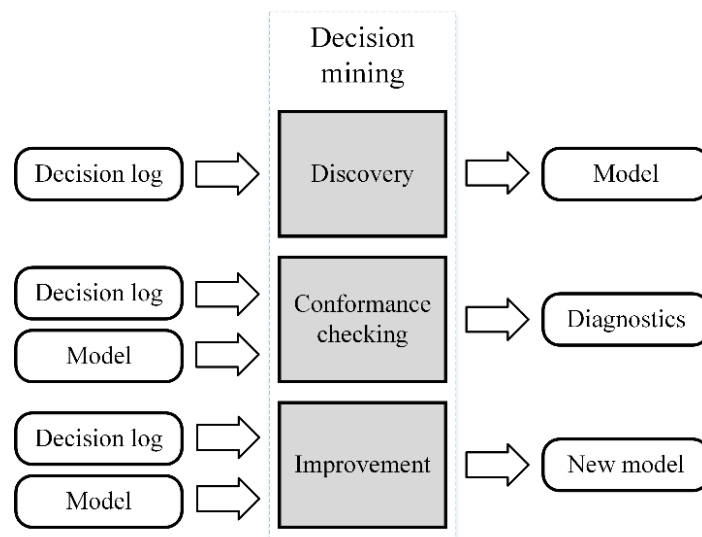


Figure 1: Decision mining fases by [7]

Several methods are dedicated to discovering, examining, and enhancing patterns in data. Data mining focuses on knowledge discovery, particularly aggregation patterns [15], while process mining [16] and decision mining [7] concentrate on process and decision patterns. Both process mining and decision mining follow a similar approach, which can be summarized into three phases: discovery, conformance checking, and enhancement or improvement of processes or decisions. Previous studies have explored the discovery of decisions from data [17]–[20].

However, researchers suggest a shift in focus from a process viewpoint focus of decision mining to a decision viewpoint focus of decision mining [7], [13], [20], [21]. Therefore, this PhD-project will focus on creating techniques for the Discovery, Conformance Checking, and Improvement of Decisions at Governmental institutions.

### 3. Research sub-questions and publications

We relate the current publication status to our identified sub-questions. We detail the studies related to the research sub-questions in section 4.

**Research question 1:** What is the current state of mining techniques which could support professionals of governmental institutions in a decision making process?

Studies:

- [7] S. Leewis, K. Smit, and M. Zoet, “Putting Decision Mining into Context: A Literature Study,” in *Lecture Notes in Information Systems and Organisation*, vol. 38, no. September, 2020, pp. 31–46.

**Status: Published**

- [22] S. Leewis, K. Smit, and M. Berkhout, “Business Rules Management and Decision Mining - Filling in the Gaps,” in *Proceedings of the 55th Hawaii International Conference on System Sciences*, 2022, pp. 6229–6238.

**Status: Published**

**Research question 2:** What are the challenges professionals at governmental institutions (may) face when utilizing decision mining?

Studies:

- [23]: S. Leewis, M. Berkhout, and K. Smit, “Future Challenges in Decision Mining at Governmental Institutions,” *AMCIS 2020 Proceedings.*, no. 6, 2020.

**Status: Published**

**Research question 3:** How can decisions be discovered, checked on conformance, and improved through decision mining at governmental institutions, while explicitly striving for positive contribution to public value?

Studies:

- DM45: Adapting and Extending the C4.5 Algorithm for the Discovery of Decisions from Structured Data through the Decision Model and Notation Standard. *Annals of Operation Research journal*.

**Status: Submitted**

- Precision and Fitness as Quality Dimensions for Decision Discovery Algorithms. *ICIS 2023*.

**Status: Submitted.**

- Analyzing and improving operational decisions at Dutch governmental institutions. A design science approach of developing a verification solution through decision mining conformance checking and improvement techniques. *Government Information Quarterly journal*.

**Status: Writing**

**Research question 4:** How can governmental institutions utilize decision mining following public value in a methodological way?

Studies:

- The Creation of a Situational Method for Decision Mining at Governmental Institutions. Creating a decision mining method through the use of method engineering. *Information and Software Technology journal*

**Status: Writing**

### 4. Research studies.

The following studies are related to the research sub-questions.

### **Study 1: Putting Decision Mining into Context: A Literature Study**

The value of a decision can be increased through analyzing the decision logic, and the outcomes. The more often a decision is taken, the more data becomes available about the results. More available data results into smarter decisions and increases the value the decision has for an organization. The research field addressing this problem is Decision mining. By conducting a literature study on the current state of Decision mining, we aim to discover the research gaps and where Decision mining can be improved upon. Our findings show that the concepts used in the Decision mining field and related fields are ambiguous and show overlap. Future research directions are discovered to increase the quality and maturity of Decision mining research. This could be achieved by focusing more on Decision mining research, a change is needed from a business process Decision mining approach to a decision focused approach. This study addresses research question 1.

### **Study 2: Future Challenges in Decision Mining at Governmental Institutions**

Decisions are made in fast-changing situations. To cope with this, decision mining could be utilized to support the decision-making process. Decision mining is an emerging field which could support an organizations decision-making process. For proper utilization of decision mining, possible challenges should be identified to take into account when mining decisions. As such, two focus groups were conducted where we identified 11 main challenges that seven Dutch governmental institutions deemed important and which should be taken into consideration when mining decisions. The identified challenges are depicted further together with existing literature and the coded observations. The identified challenges could be utilized as future research directions and are discussed as such.. This study addresses research question 2.

### **Study 3: Business Rules Management and Decision Mining - Filling in the Gaps**

Proper decision-making is one of the most important capabilities of an organization. Adequately managing these decisions is therefore of high importance. Business Rules Management (BRM) is an approach which helps in managing decisions and underlying business logic. However, questions still arise if the decisions are properly improved based on decision data. Decision Mining (DM) could complement BRM capabilities in order to improve towards effective and efficient decision-making. In this study, we propose the integration of BRM and DM through a simulation using a government and a healthcare case. During this simulation, three entry points are presented that describe how decision-related data should be utilized between BRM capabilities and DM phases to be able to integrate them. The presented results provide a basis from which more technical research on the three DM phases can be further explored. This study addresses research questions 2 and 3.

### **Study 4: The discovery of decisions from data through decision mining**

Analyzing decisions-related historical data can help support actual decision-making. Decision mining could be used for such analysis. This paper pro-poses an adapted C4.5 algorithm, through which operational decisions from structured data can be discovered and presented as a decision model, utilizing the Decision Model and Notation (DMN) standard. The proposed adaptations consist of 1) the necessity of structured data input, the so-called decision log, 2) the generation of an unpruned decision tree, 3) the discovery of decision rules, 4) the mapping of discovered decisions in DMN, and 5) the normalization of the resulting decision table. The adapted C4.5 algorithm, named DM45, is tested using the Titanic dataset and Sepsis dataset, which resulted in a comprehensible, understandable, manageable, and executable DMN. Future research can focus on supporting practitioners in modelling decisions, checking whether their decision-making is compliant, as well as by suggesting improvements to the modelled decisions. Another direction for future research suggests the ability to process un-structured data as input data for the discovery of decisions. This study addresses research question 3.

### **Study 5: Precision and Fitness as Quality Dimensions for Decision Discovery Algorithms**

High-volume operational decisions generate large amounts of data that can be analyzed to improve decision-making. Process and decision mining are methods that use algorithms to discover, analyze and improve processes and decisions. However, these algorithms face challenges due to the uncertainties and noise present in real-world data and the limitations and assumptions of the algorithms. Therefore, the specific focus of the discovery algorithms needs to be evaluated. The process mining quality dimensions provide such evaluation criteria for process mining discovery algorithms. Given the similarities between process mining and decision mining, the process mining quality dimensions have

potential for the decision mining domain where no quality dimensions have been identified. Precision and fitness quality dimensions have been adapted to incorporate the unique elements of a decision and its decision modelling language. Future research should focus on adapting the remaining quality dimensions of simplicity and generalization for the decision mining domain. This study addresses research question 3.

**Study 6: Analyzing and improving operational decisions at Dutch governmental institutions.**

Decision Mining is a method encompassing three distinct phases: Discovery, Conformance Checking, and Improvement. This study focuses on extending the capabilities of Decision Mining by incorporating the Conformance Checking and Improvement phases, which are currently lacking in the existing tool. Decision Mining involves extracting insights from decision logs for rule creation, compliance verification, and performance evaluation. While Process Mining has received considerable research attention, the implementation of the Improvement phase in Decision Mining remains underexplored. To bridge this gap, the Design Science methodology is employed, combining literature review and iterative software development. The Conformance Checking phase is found to be essential for the Improvement phase, providing diagnostic input and iterative model refinement. To mitigate risks and enhance user control, a manual approach is chosen for model modifications, utilizing visual cues to identify improvement areas. By integrating these phases, this research contributes to advancing decision analysis techniques, enabling more effective decision-making in diverse domains. The results of study 1, 2, and 3 are used in this study. This study addresses research question 3.

**Study 7: The decision mining method**

Results of study 1, 2, 3, 4, 5, and 6 are used as part of the decision mining method created in this study (research question 4). This method should guide future decision-makers in utilizing decision mining conforming public value. The decision mining method is created through method engineering [24] taking into account public value using principles of Value Sensitive Design [25]. The decision mining method is constructed with method engineering using the results of study 1, 2, 3, 4, 5, and 6. Subsequently, focus groups are conducted to validate the created decision mining method. The focus groups consist of stakeholders of which day to day activities consists out of writing business rules, analysing laws, regulations and business rules. The focus groups validate the decision mining method in adhering to public value consisting of three rounds. Round one focusses on presenting the initial Method which is created based on the results of the previous studies. After round one the researcher will summarize and consolidate the discussed views of the participants. The results are sent to the participants with the request to assess the results. In round two and three, the results of the previous rounds are discussed with the aim to put in any additions to their previous answers and to evaluate the changes in the method.

This study addresses research question 4.

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