The Decision Transparency Framework:

A framework and key transparency indicators to measure the business decisions and business logic transparency

Completed Research Paper

Martijn Zoet **Koen Smit**

Abstract

Business decisions and business logic are an important part of an organization's daily activities. In the not so near past they were modelled as integrative part of business processes, however, during the last years, they are managed as a separate entity. Still, decisions and underlying business logic often remain a black box. Therefore, the call for transparency increases. Current theory does not provide a measurable and quantitative way to measure transparency for business decisions. This paper extends the understanding of different views on transparency with regards to business decisions and underlying business logic and presents a framework including Key Transparency Indicators (KTI) to measure the transparency of business decisions and business logic. The framework is validated by means of an experiment using case study data. Results show that the framework and KTI's are useful to measure transparency. Further research will focus on further refinement of the measurements as well as further validation of the current measurements.

Keywords: Business Decisions, Business Logic, Transparency, Key Transparency Indicators, Framework

Introduction

Business Process Management and Decision Management both study the management and execution of tasks (van der Aalst, ter Hofstede, & Weske, 2003). Business Process Management (BPM) takes an activity/resources viewpoint, while Decision Management approaches tasks from a guideline/knowledge viewpoint. On the one hand, BPM uses methods, techniques and software to design, enact, control and analyze operational processes (Weske, 2012). While on the other hand, specific tasks within the process, such as *"determine risk profile"*, are decisions (Blenko, Mankins, & Rogers, 2010; Rogers & Blenko, 2006). The notion that the decision and underlying business logic should be managed as a separate entity has strengthened in the last years, as is described in the business rules management and decision management field (Boyer & Mili, 2011; Morgan, 2002; Nelson, Rariden, & Sen, 2008; Zoet, 2014) as well as the business intelligence field (Chen, Chiang, & Storey, 2010).

In addition to the trend that decisions are a separate entity an additional trend influences Decision Management: the call for transparency. For example, the new General Data Protection Regulation (GDPR) in the European Union demands specific transparency with regards to operational decisions that are integrated into the daily business processes. Yet, in current literature, the framework to measure transparency in decision-making are predominantly focusing on a tactic and strategic level (Grimmelikhuijsen & Welch, 2012). For example, (Drew & Nyerges, 2004) in their study propose a framework for transparency existing out of seven elements: integration into broader decision context, clarity, accessibility, openness, accountability, truth and accuracy, logic and rationale. How to exactly quantitatively measure these elements is not presented. Another example is the transparency cube proposed by (Brandsma & Schillemans, 2012), which has three elements: consequence, information and discussion, with the following related measures: from few to many, little too much and intensive to non-intensive, which are also not very specific. Therefore, we argue that these frameworks are still not normative and, in addition, not useful for operational decisions. This article extends the understanding of transparency for decision-making by developing a comprehensive framework for evaluating transparency for operational decisions. With these premises, the following research question is addressed: *"How can the transparency of an operational decision be quantitatively evaluated?"* Answering this question will help organizations to evaluate the actual transparency of their decisions and underlying business logic.

The paper is organized as follows. First, we define transparency, which is the fundament of our research, after which the objects of transparency are presented and the measurements for transparency per area explained. Section three describes the research method and case selection. This is followed by the results of the experiment, which are presented in section 4. Section 5 discusses the experiment validity and limitations. We conclude and summarize our research in section 6.

Background and Related Work

Transparency is a multidimensional concept that dependents on A) the object of transparency, B) the situational factors affecting transparency, C) the spin tactic, and D) the relation between objects (Raynolds, 2009). To deal with the definitional ambiguity of the term transparency, each previously mentioned element needs to be addressed when defining transparency for a specific area. Examples of areas in which transparency can be applied are monetary policy, democracy and trade policy, business decisions and business processes. The object of transparency in this research is a business decision and its underlying business logic. A business decision is defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing*" (Object Management Group, 2016a), from here on referred to as a decision. Moreover, business logic is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016b).

In theory as well as practice, multiple concepts exist to express decisions and underlying business logic. For example, business logic can be represented by means of decision tables, decision trees, or structured languages (Vanthienen, 2001; Von Halle & Goldberg, 2009; Zoet, Ravesteyn, & Versendaal, 2011). Still, there is a general consensus on the overall artefacts in the lifecycle of a decision, which are: 1) source, 2) decision service, 3) decision, 4) decision question and 5) data. In this work, the focus will be on defining transparency for a decision service and its underlying decisions. Transparency of the decision service and underlying decisions are influenced by the phase of the lifecycle. For example, when a decision needs to be specified in full transparency, the decision and underlying business logic need to be explicit and accessible. Else the decision might be wrongfully coded into the software system. However, when the decision is executed, an organization can choose to hide the manner in which the decision is executed and only show input fields for the data it needs to execute the decision. Therefore, lifecycle is defined as a situational factor. The lifecycle of a decision exist out of nine phases, namely: 1) elicitation, 2) design, 3) specification, 4) verification, 5) validation, 6) deployment, 7) execution, 8) evaluation and 9) governance, see for example (Boyer & Mili, 2011; Nelson & Sen, 2014; Schlosser, Baghi, Otto, & Oesterle, 2014). In this paper, we will only focus on the describing the parts of the lifecycle that affect the transparency. These nine phases have been described in detail in (Smit, 2018), while specific parts and challenges regarding every phase have been described in (Smit, Versendaal, & Zoet, 2017; Smit, Zoet, & Versendaal, 2018; Smit & Zoet, 2018).

The spin tactic depends on the combination of the object and the lifecycle phase, for example, only showing specific elements of the decision during execution. The spin tactics applied will be further elaborated in the next paragraphs. The last element, the relation between objects, indicates if traceability between the objects exists. Traceability plays a significant role in information systems research and practice and has been studied in detail, therefore this needs to be taken into account when defining transparency of a decision service and its underlying decisions. In this paper, the focus is the transparency of the decision service and its underlying decisions, therefore, no transparency measurements will be defined with regards to the source, decision questions and data. However from a traceability perspective, the link between the decision service & underlying decisions, and the source, decision question and data will be taken into account.

In the remainder of this section, the transparency demands and the way in which to measure them will be presented per object, see the vertical axis in Figure 1. Moreover, the underlying transparency between the different objects is discussed. To help ground the explanation of transparency in the context of a decision, we already present the decision transparency framework in Figure 1.

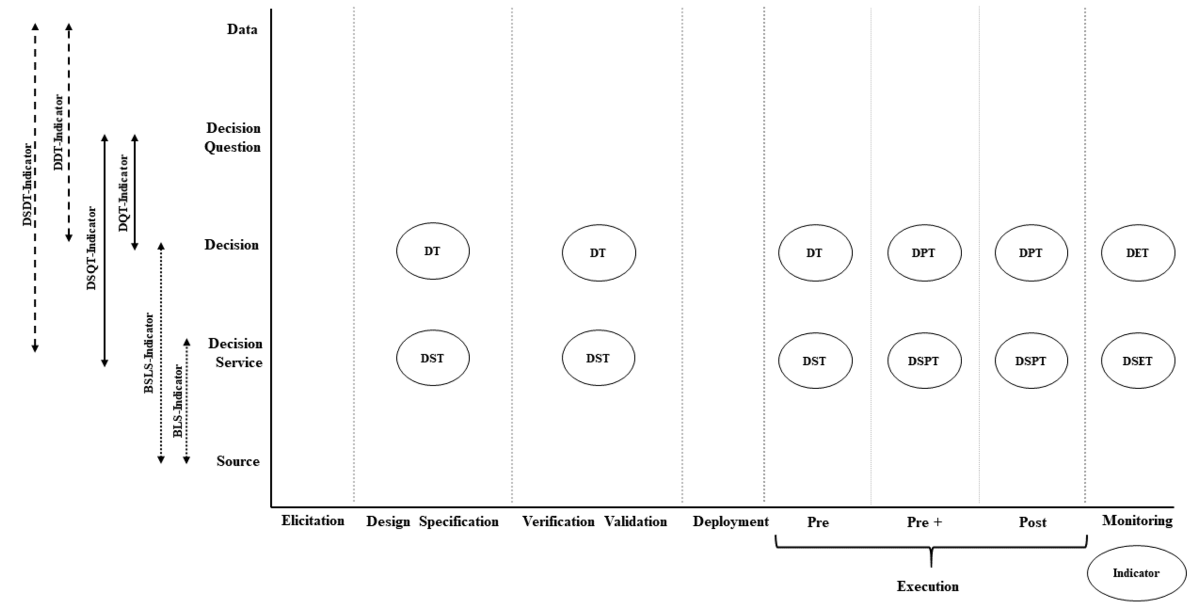

Figure 1. The decision transparency framework

Object of Transparency #1: Decision

From an information/engineering perspective, business logic is an (Hay, Healy, & Hall, 2000; Von Halle & Goldberg, 2009): *"**expression** that evaluates **conditions**, by means of a calculation or classification, leading to a **conclusion.**"* Decomposing this definition results in three different elements, **namely**: 1) conditions, 2) expression and, 3) conclusion. The condition can be further decomposed into two elements: the condition fact-type and the condition-fact values (Von Halle & Goldberg, 2009). For example, the condition fact-type is *"weather temperature"* while the condition-fact value is *"16 degrees Celsius"*. The same applies to the conclusion, which also exists out of a conclusion fact-type and conclusion-fact values. The manner in which the expression, conditions and conclusions are represented to a user can vary. For example, business logic formulated in Structured English can state the following: *"if the weather temperature is 16 degrees Celsius then preferred clothing is equal to jacket."* However, the same statement can also be described in first order logic. Still, the manner in which transparency can be determined remains the same, are the conditions, expression and conclusion accessible for a specific role at a specified time?

Insight Indicator 1: Decision Transparency Indicator

The Decision Transparency Indicator (DT- Indicator) indicates the accessibility to the expression, conditions-fact(s), conditions facts-values, conclusion-fact, and conclusion fact-values of an individual decision for a specified stakeholder at a specified moment. Accessibility in this formula means that the different variables in the formula (e.g. CDFT and CDFV) are available to be examined by a specific stakeholder. The following formula is applied to calculate the DT-Indicator:

$$\text{DT- Indicator} = \sum (\text{CDFT, CDFV, CLFT, CLFV, EXPR, MC}).$$

Formula 1. Calculate the DT-Indicator

Where the variable CDFT (Condition Facttype) denotes the visibility of the condition fact(s). The variable CDFT can have the value 0 or 1. The value 0 indicates that the condition fact-type(s) are invisible while the value 1 indicates that they are visible. In addition, the variable CDFV (Condition FactValue) denotes the visibility of the condition fact-values and can have the value 0 (invisible) or 1 (visible). The value of the variable CDFT conditions the possible value CDFV can set. If the CDFT is set to value 0, the value of CDFV will automatically also be set to 0. This is caused by the relationship between the condition-facts and condition fact-values. If only the condition fact-values are present without any additional information, they are multi-interpretable. For example, a form contains the fact-values: 0, 1, 2 and 3, without any additional information. The range of figures can mean anything. To have any value, the condition-fact, for example, endurance of pain, must be known. If the value of CDFT is set to value 1, the value of CDFV can be either 0 or 1. The variables CLFT (Conclusion Facttype) and CLFV (Conclusion FactValue) follow the same patterns as the variables CDFT and CDFV. Both CLFT and CLFV can have their values set to 0 (invisible) or 1 (visible). In addition, the same restriction on the relationship between CLFT and CLFV exists. If the variable CDFT is set to value 0, the value of CLFV will automatically also be set to 0. If the value of CDFT is set to value 1, the value of CDFV can be either 0 or 1. EXPR denotes the visibility of the expression between the condition-facttype(s) and conclusion facttype. The variable EXPR can have the values 0 or 1. Where the value 0 indicates invisible and 1 visible. The values of CDFT and CLFV conditions the possible values EXPR can set. If either CDFT or CLFV is set to 0, EXPR will automatically also be set to 0, since the total expression cannot be shown without the condition or conclusion. The last variable is the mask condition variable (MC). Mask conditions are conditions that are not used to determine the conclusion, but are added to hide the actual condition that is applied. For example, if the conclusion *"Risk Value"* is derived from the conditions *"A"*, *"B"* and *"C"*, but to hide this additional conditions are added, for example *"D"* and *"E"*. In this case "D" and "E" are defined as mask conditions. Mask conditions exist or do not exist, therefore MC can have the 0 (exist) or 1 (do not exist). The total score this formula can result in is six. The level of transparency the organization wants to deliver depends on the actual organisation. In the formula to calculate the DT-indicator, the factors are assigned equal weight, the same applies to the remainder of the formulas described. This is due to the fact that, in this first cycle of the research, the focus must lie on the use and usefulness of the formulas (Hevner, March, Park, & Ram, 2004). Further research will focus on validating the appropriate weight to the different factors.

The DT-Indicator can be applied to determine the transparency of a decision in the elicitation, design, specification, verification, validation and deployment phases. From an engineering perspective, the execution phase also is one phase and the DT-Indicator could be applied. However, from a legal perspective, the execution phase is divided into multiple sub-phases. Depending on the literature the execution phase is divided into two or three phases (European Union, 2016b; Grimmelikhuijsen & Welch, 2012). In this research we adhere to the new GDPR legislation in the European Union and therefore divided the execution phase into three sub-phases: 1) pre-execution phase, 2) pre+-execution phase and, 3) post-execution phase. To explain the difference between the three phases an example is provided here, based on a user filling in a form. The pre-execution phase is the phase in which a user is entering data into the digital form. This phase ends when the user presses a button to submit the entered data. A screen now appears which shows the results of the data entered, this is the pre+-execution phase. Which is the moment that the user entered data, pressed the button and gets a screen with the data entered, but the actual decision has not been made, yet. When the user presses the button to approve the data, the actual decision is made. The phase after this is called the post-execution phase.

In the pre-execution phase, the DT-Indicator can be applied to calculate the transparency. However, for the pre+-execution phase and the post-execution phase an additional decision artefact is recognized, the decision path. The decision path indicates, for a specific case, which condition fact-values have been triggered and which conclusion fact-value is reached. Therefore, to reach full transparency, an additional element needs to be taken into account. This is an additional key transparency indicator, decision path transparency indicator.

Insight Indicator 2: Decision Path Transparency Indicator

The Decision Path Transparency Indicator (DPT-Indicator) indicates the accessibility to the expression, conditions-fact(s), conditions facts-values, conclusion-fact, and conclusion fact-values, and decision path of an individual decision. The following formula is applied to calculate the DT-Indicator:

$$\text{DPT-Indicator} = \sum (\text{CDFT, CDFV, CLFT, CLFV, EXPR, MC, Path}).$$

Formula 2. Calculate the DT-Indicator

To calculate the DPT-Indicator an extension is added to the formula used to calculate the DPT-Indicator. The first six variables are the same, namely: CDFT, CDFV, CLFT, CLFV, EXPR and MC, while an additional variable Path is added. The variable Path can be set to value 0 (invisible) or 1 (invisible). The value of the variables CDFT, CDFV, CLFT, CLFV, EXPR condition the possible value Path can set. If either CDFT, CDFV, CLFT, CLFV or EXPR is set with a value 0, the value of Path will automatically be set to 0. Since the transparency of all the previous elements is required to show the Path. The total score the DPT-Indicator can be seven. The level of transparency the organization wants to deliver depends on the actual organisation.

Insight Indicator 3: Decision Execution Transparency Indicator

The last phase of the decision lifecycle is the monitoring phase. In the monitoring phase analysis is performed with regards to an individual execution or a set of executions. Transparency in this phase equals the number and type of analysis a specific stakeholder can execute at a specific time. However, the type of analysis and the number of analyses vary between different organizations and are influenced by laws and regulations. The Decision Execution Transparency Indicator (DET-Indicator) indicates the access of a specified stakeholder at a specified moment to the standard analysis of an individual decision. Where standard analysis is defined as the analysis an organization minimally wants to be able to conduct. The following formula is applied to calculate the DET-Index:

$$\text{DET- Indicator} = \sum (\text{Analysis 1, Analysis 2, Analysis 3, Analysis n'th}).$$

Formula 3. Calculate the DET-Indicator

Where Analysis 1 till 3 denotes the possibility to retrieve the specific analysis. An additional variable can be added for each additional analysis the organisation needs or must perform. Each variable can have the values 0 (invisible) or 1 (visible). Full transparency is reached when each analysis is set to 1, for each variable set to 0 the transparency diminishes.

Object of Transparency #2: Decision Service

The previous object of transparency is a single decision, however, decisions are often part of a decision service (also known as business rule architecture). A decision service consists of two or more decisions and a derivation structure. The derivation structure depicts the relationship between the individual decisions. Therefore, the decision service is the sum of all underlying decisions. Thereby the transparency of the decision service is the sum of the transparency of underlying decisions plus the transparency of the derivation structure. The three indicators for the decisions are adjusted to be useful for the decision service.

Insight Indicator 4: Decision Service Transparency Indicator

The Decision Service Transparency Indicator (DST-Indicator) indicates the accessibility to the derivation structure, condition fact(s), conditions facts-values, conclusion fact-type and conclusion fact-values of a set of decisions (decision service) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DST-Indicator:

DST- Indicator = (Average DT-Indicator) * (Variable Interconnection-Score)

Formula 4. Calculate the DST-Indicator

The average DT-Indicator is the average DT-Indicator of all underlying decisions in the decision service. For example, if a decision service consists of seven individual decisions the DT-Indicator score of those seven individual decisions is averaged. This score is multiplied by the variable interconnection score (VI-Score) which is calculated as follows:

Variable Interconnection-Score = (1 – (maximum connections – actual connections) / 100).

Formula 5. Calculate the interconnection score

Where the maximum connections are the number of connections between the individual decisions in the decision service. The number of maximal connections is calculated by the number of decision – 1. See for example figure 2, which exists out of four decision: A, B, C and D. Decision A, B, C and D are connected to each other through three connections: connection 1, 2 and 3. The actual connections are the connections that are visible in the decision service.

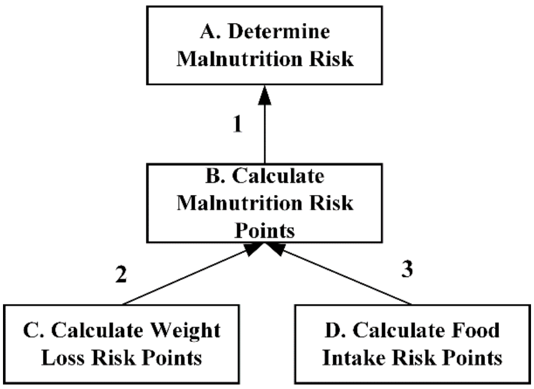

Figure 2. Example Decisions

Insight Indicator 5: Decision Service Path Transparency Indicator

The Decision Service Path Transparency Indicator (DSPT-Indicator) indicates the accessibility to the expression, conditions-fact(s), conditions facts-values, conclusion-fact conclusion fact-values, and the decision path of a specific set of decisions (decision service) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DSPT-Indicator:

DSPT- Indicator = (Average DPT- Indicator) * (Variable Interconnection-Score)

Formula 6. Calculate the DSPT-Indicator

Insight Indicator 6: Decision Service Execution Transparency Indicator

The Decision Service Execution Transparency Indicator (DSET-Indicator) indicates the accessibility to the standard analysis (DET-Indicator) of a specific set of decisions (decision service) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DSET-Indicator:

DSET-Indicator = (Average DET-Indicator) * (Variable Interconnection Score)

Formula 7. Calculate the DSET-Indicator

Transparency between Objects: Traceability

As mentioned earlier in this section the second form of transparency is the transparency between objects. In this specific research, this implies the transparency between the decision service & underlying decision(s) and the three other artefacts: 1) the source, 2) decision questions and 3) data.

The source indicates where the knowledge is elicitated from to design and specify the decision and underlying business logic (Debevoise, Taylor, Sinur, & Geneva, 2014). In research, different types of sources from which knowledge can be derived exist, for example, human experts, documentation and/or data. Data indicates the data that is required to evaluate the condition-facts in a decision. In some cases this data needs to be retrieved from third-parties, for example, citizens or other organizations. To realize this, input forms with questions are built or API's can be connected. The connection, either being a question on a form or API is defined as a decision question. To reach optimal transparency, each decision, and therefore the entire decision service, needs to be able to be traced to the specific source(s), data and decision question(s), see Figure 1. To determine the degree of transparency, six measurements have been defined: 1) Decision Data Transparency Indicator, 2) Decision Service Data Transparency Indicator, 3) Decision Question Transparency Indicator, 4) Decision Service Question Transparency Indicator, 5) Business Logic Source Indicator and, 6) Business Logic Source Indicator. Since the first three formulas apply the same pattern and the last three formulas also apply the same pattern, first the pattern will be, based on the Decision Data Transparency Indicator, explained after which the remaining indicators will be presented.

Traceability Indicator 1: Decision Data Transparency Indicator

Condition-fact(s) and the conclusion-fact are related to the data required to execute the decision. For example, a decision with three condition-facts: *"a"*, *"b"* and *"c"* needs three data elements matched to these three condition-facts. Therefore, to determine the degree of transparency, the visibility of the relationship between the data and condition-fact and conclusion-fact needs to be established. This is depicted in the following manner:

Condition-Fact -> Data
Condition-Fact -> Data
Condition-Fact n'th -> Data
Conclusion-Fact -> Data

Formula 8. Determine relationship between Condition-Facts and Data

For every condition-fact and conclusion-fact it has been determined if this relationship exists. For example, if a decision exists out of 3 condition-facts, the following relationship could exist:

Condition-Fact A -> Data Element, 1
Condition-Fact B -> Data Element, 1
Condition-Fact C -> Data Element, 0
Conclusion-Fact -> Data Element, 1

Formula 9. Determine value to calculate the DSET-Indicator

In this specific example, the data elements are known for condition fact A, B and the conclusion fact. The same logic applies to the source and decision question. To determine the transparency of the data elements the following formula is applied:

DDT-Indicator = (∑ (Condition-Fact Data Score) + Conclusion-Fact Data Score / (∑ (Number of Conditions) + 1)) *100.

Formula 10. Calculate the BLS-Indicator

Which in this specific example would result in:

DDT-Indicator = ((2 + 1) / 4 * 100) = 75.

Formula 11. Calculate the BLS-Indicator

In addition to the data, the same relationships apply to the source and the decision question. For example, the fact that the condition-fact *"risk"* should represent in a decision can be found in regulation Y, Condition-Fact -> Source. In addition, the fact-value for risk is registered in a specific database, from which the value is retrieved to execute the decision. Also, if the fact-value first needs to be retrieved, the condition-fact must be matched with a decision question, Condition-Fact -> Decision Question. Therefore, the same formulas with different variables apply.

Traceability Indicator 2: Decision Service Data Transparency Indicator

The Decision Service Data Transparency Indicator (DSDT-Indicator) indicates the accessibility to the relationship between a set of decisions (decision service) and the data applied to execute the set of decisions (decision service) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DSDT-Indicator:

DSDT-Indicator = (Average DT-Indicator) * (Variable Interconnection Score)

Formula 12. Calculate the DST-Indicator

Traceability Indicator 3: The Decision Data Question Indicator (DQT-Indicator)

The Decision Data Question Indicator (DQT-Indicator) indicates the accessibility to the relationship between an individual decision and the question applied to retrieve the data needed to execute the individual decision (decision question) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DQT -Index:

DQT-Indicator = (∑ (Condition-Fact Question Score) + Conclusion Question Score / (∑ (Number of Conditions) + 1)) *100.

Formula 13. Calculate the DQT-Indicator

Traceability Indicator 4: The Decision Service Data Question Indicator (DSQT-Indicator)

The Decision Service Data Question Indicator (DSQT-Indicator) indicates the accessibility to the relationship between a set of decisions (decision service) and the questions applied to retrieve the data required to execute the set of decisions (decision service) for a specified stakeholder at a specified moment. The following formula is applied to calculate the DSQT-Indicator:

DSQT-Indicator = (Average DQT-Indicator) * (Variable Interconnection Score)

Formula 14. Calculate the DSQT-Indicator

Traceability Indicator 5: Business Logic Transparency Indicator

The Business Logic Source Indicator (BLS- Indicator) indicates the accessibility to the relationship between the decision and the source on which the decision is based for a specified stakeholder at a specified moment Every Indicator, except the BLS-Indicator, is calculated with one specific formula. The reason the BLS-Indicator cannot be calculated with one single formula is caused by the different source types that can be used to specify the decision and underlying business logic. One type of source is documentation. The relationship between the decision, and underlying business logic, and documentation (i.e. laws and regulations) can be calculated with current techniques, see formula 15. For another source, data, the challenge is relating different parts of the design of the decision and underlying business logic to specific data elements. On the one hand, when traditional machine learning is applied, this is still possible by analyzing the data, using regressions and additional formulas. On the other hand, when neural networks or reinforcement learning algorithms are applied, researchers did not, yet, find a way in which this can be done. Therefore, for this specific study, only the relationship between decisions and written documentation is addressed, which is calculated as follows:

BLS-Indicator = (∑ (Condition-Fact Logic Score) + Conclusion Logic Score / (∑ (Number of Conditions) + 1)) *100.

Formula 15. Calculate the BLS-Indicator

Traceability Indicator 6: Business Service Logic Transparency Indicator

The Business Service Logic Transparency Indicator (DSBLS-Indicator) indicates the accessibility to the relationship between a set of decisions (decision service) and the source that the decision and underlying business logic is based on for a specified stakeholder at a specified moment. The following formula is applied to calculate the DSBLS-Indicator:

DSBLS- Indicator = (Average BLS-Indicator) * (Variable Interconnection Score)

Formula 16. Calculate the DSBLS-Indicator

Research Method

The goal of this study is to identify and validate performance measurements that provide insight into the transparency of a decision service and its underlying decisions. A traditional literature study was conducted, with the aim to identify performance measurements suitable for expressing transparency. Based on this literature study, twelve performance measurements have been defined. The second goal of this study is to evaluate the usefulness and applicability in a real-life case. An appropriate research method to evaluate the usefulness and applicability of a product, being a method, framework or categorization, is an experiment based on case study data. This research method allows us to use data from an actual case while fully controlling the execution of the method and the input variables.

The case study was selected based on one theoretical and one practical criterion. Firstly, the case had to provide: 1) a decision service 2) with underlying decisions, 3) business logic, and 4) the application of previously mentioned artefacts during the lifecycle. Secondly, the organization had to be willing to provide the details needed to perform the experiment. Based on these criteria the *"Type of Child Benefit"* case from the Social Security Bank in The Netherlands was chosen. The case exists out of one decision service with 16 underlying decisions.

The evaluation, by means of conducting an experiment, was divided into three phases. Phase one was used to make the researchers familiar with the case parameters, by analyzing 69-pages that describe the decision service, decisions and underlying business logic. Also, the additional information required to make the calculation has been collected. During the second phase, the measurements have been calculated. The measurements have been evaluated during the third phase.

Case Study

First, the insight KTI's will be demonstrated on a single decision within the decision service, after which the Traceability Indicator KTI's will be demonstrated. This section will conclude with the demonstration of the insight KTI's and traceability Indicator for decision services. The decision evaluated is: *"determine learning and qualification obligation child"*. The decision exists of out three conditions facts: *"child lives in the Netherlands"*, *"child meets criteria 1969"*, and *"child meets dispensation criteria"*. Furthermore, the decision has one conclusion fact: *"learning and qualification obligation child"*. In total, four business rules have been defined to evaluate the decision, see Figure 3.

Rule Pattern	Child lives in the Netherlands	Child meets 1969 criteria	Child meets dispensation citeria	Child learning and qualification obligation
1	*FALSE*	-	-	*FALSE*
2	*TRUE*	*TRUE*	-	*TRUE*
3	*TRUE*	-	*TRUE*	*TRUE*
4	*TRUE*	*FALSE*	*FALSE*	*FALSE*

Figure 3. Decision – Child learning and qualification obligation

First, the DT-Indicator for the design & specification transparency and the DT-Indicator pre-execution transparency are calculated. For the first DT-Indicator the stakeholder are the modelers designing and specifying the derivation structure as well as the business rules, in this case, the same group of people. For each variable in the formula, the value must be determined, in this case, respectively, CDFT = 1, CDFV = 1, CLFT = 1, CLFV = 1, EXPR = 1, MC = 1. The total DT-Indicator score for the modelers is:

$$\text{DT- Indicator} = (1 + 1 + 1 + 1 + 1 + 1) = 6 = 100\% \text{ Transparency.}$$

Equation 1. DT-Indicator score for the modellers

The second DT- Indicator is calculated for the customer who fills in the digital forms to determine the results for the decision service: *"determine eligibility type of child benefits"*. In this case, the stakeholders are solely the clients; the formula shows a reduction in transparency as the clients do not have transparency with regards to the derivation structure. There has been some debate by the researchers as mask conditions exist. The reason for this debate is the fact that the digital form asks for more input than the variables required to executed the decision *"determine learning and qualification obligation child*" since the conditions are all clustered on the form, the decision has been made that no mask conditions exist. Therefore, the values to apply in the formula are in this case, respectively, CDFT = 1, CDFV = 1, CLFT = 0, CLFV = 0, EXPR = 0, MC = 1. The total DT-Indicator score for the clients is:

$$\text{DT- Indicator} = (1 + 1 + 0 + 0 + 0 + 1) = 3 = 50\% \text{ Transparency.}$$

Equation 2. DT-Indicator score for the clients

After the DT- Indicator is calculated, the DPT- Indicator can be calculated. In both cases the stakeholders are the clients. At the Pre+ Execution transparency moment, the clients only have access to the data they entered in the digital form. Therefore, the values to apply in the formula are in this case, respectively, CDFT = 1, CDFV = 1, CLFT = 0, CLFV = 0, EXPR = 0, MC = 1, Path = 0. The total DPT-Indicator score for the clients at Pre+ Execution is:

$$\text{DPT-Indicator} = (1 + 1 + 0 + 0 + 0 + 1 + 0) = 3 = 42{,}8\% \text{ Transparency.}$$

Equation 3. DPT-Indicator score for the clients

With respect to the Post-Execution Transparency, the information shown to the client changes, all previously entered information disappears and only the conclusion of the decision is shown. Therefore, the values to apply in the formula are in this case, respectively, CDFT = 0, CDFV = 0, CLFT = 1, CLFV = 1, EXPR = 0, MC = 1, Path = 0. The total DPT- Indicator score for the clients at Post Execution is:

$$\text{DPT-Indicator} = (0 + 0 + 1 + 1 + 0 + 1 + 0) = 3 = 42{,}8\% \text{ Transparency.}$$

Equation 4. Post-Execution DPT-Indicator score for the clients

The last insight variable is the DET-Indicator, which is determined at the monitoring phase. In this case, no stakeholder was responsible and no formal reporting was performed. Only informal reports based on ad-hoc questions are created. Therefore, the DET-Indicator isn't calculated.

The first traceability indicator that was calculated is the Business Logic Source Indicator (BLS-Indicator). In case of the SSB, the stakeholder responsible for this are the rule modellers. They couple every condition-fact and conclusion-fact to a specific part of a law or regulation (source). Therefore, the values to apply in the formula are, CDBL1 (child lives in the Netherland) = 1, CDBL 2 (child meets criteria 1969) = 1, CDBL 3 (child meets dispensation criteria) = 1, and CLBL (learning and qualification obligation child) = 1.

$$\text{BLS-Indicator} = ((\text{sum }(1, 1, 1)) + 1) / 4) * 100 = 100\% \text{ Transparency}$$

Equation 5. BLS-Indicator score for modellers

The second traceability indicator is the DDT-Indicator. In this case, the stakeholders are solely the modellers of the business logic who also maintain the coupling between the business logic and the data elements. The advantage of centralizing both elements together is that the transparency indicator is high since each element can individually be traced. Therefore, the values to apply in the formula are in this case, respectively, CDDC1 (child lives in the Netherland) = 1, CDDC2 (child meets criteria 1969) = 1, CDDC3 (child meets dispensation criteria) = 1, and CLDC (learning and qualification obligation child) = 1.

DDT-Indicator = ((sum (1, 1, 1)) + 1) / 4) * 100 = 100% Transparency

Equation 6. DDT-Indicator for modellers

The last individual transparency and traceability indicator is the DQT-Indicator. In this specific case, no formal person was responsible to realize this form of transparency. Not any of the modellers, form builders, or website builders were responsible. The only one that actually knows how to realize this was the programmer, but this role didn't register the combination and traceability between the different elements. Therefore, the values to apply in the formula are in this case, respectively, CDQC1 (child lives in the Netherland) = 0, CDQC2 (child meets criteria 1969) = 0 and, CDQC3 (child meets dispensation criteria) = 0.

DQT-Indicator = ((sum (0, 0, 0)) + 0) / 3) * 100 = 0% Transparency.

Equation 7. DQT-Indicator Calculation

In addition to the decision: *"determine learning and qualification obligation child"*, also, the indicators for the additional 15 decisions have been calculated. In this specific case, the indicators for each individual decision are identical. This is caused by the fact that the Social Security Bank has a standard set of guidelines on how they should define decisions and underlying business logic. Therefore, each decision service that has been implemented should score identically. This also has an additional effect. The DST-Indicator, DSPT-Indicator, DSET-Indicator, BSLS-Indicator, DSDT-Indicator and DSQT-Indicator are all weighted averages of the individual scores combined with the value for the transparency of the derivation structure. Therefore, in this specific case, it only has to be determined in which lifecycles the derivation structure is visible or not visible to perform the remainder of the calculations. In the case of the SSB, the derivation structure is shown in the DT-Indicator for Elicitation and Design and the DDT-Indicator. In all other cases the derivation structure is not visible leading to the following equations:

DST-Indicator design and elicitation = (100% * (1 - (difference (15,15) / 100))) = 100% Transparency.

DST-Indicator pre execution = (50% * (1 - (difference (15,0) / 100))) = 42,5% Transparency.

DSPT-Indicator pre+ execution = (42,8% * (1 - (difference (15,0) / 100))) = 36,42% Transparency.

DSPT-Indicator post execution = (42,8% * (1 - (difference (15,0) / 100))) = 36,42% Transparency.

DSDT-Indicator = (100% * (1 - (difference (15,0) / 100))) = 85,00% Transparency.

DSBL-Indicator = (100% * (1 - (difference (15,0) / 100))) = 85,00% Transparency.

DSQT-Indicator = (0% * (1 - (difference (15,0) / 100))) = 0,00% Transparency.

Equation 8. Remaining calculations SSB Case

Experiment Evaluation

After the experiment was finished an evaluation of the usefulness and applicability of the measurement is performed. Overall, the conclusion is that each of the twelve defined indicators are useful and applicable. Also, because of the new GDPR regulation in article 22 and 38 demand transparency with respect to certain indicators, in this specific case: DT-Indicator, DST-Indicator, DPT-Indicator, DSPT-Indicator, DET-Indicator and DSET-Indicator. In a Dutch context, this is strengthened by the AERIUS arrest, which also states that for government institutions the DT-Indicator, DST-Indicator, DPT-Indicator, DSPT-Indicator, BLS-Indicator, and BSLS-Indicator should be transparent. Still, some additional remarks have been made. The first remark concerns the calculation of the Mask Condition in the DT-, DST-, DPT- and DSPT-Indicator. Currently, the number of mask conditions is not taken into account in the calculation. According to the researchers, the measurement could be improved by adding this the formula. In the current situation, the transparency of the DET- and DSET-indicators are mainly guided by specific laws and regulation, i.e. the reporting demands of the regulations.

Experiment Validity

Internal validity threats, when conducting controlled experiments, can be classified into nine categories: 1) ambiguous temporal precedence, 2) selection, 3) history, 4) maturation, 5) regression, 6) attrition, 7) testing, 8) instrumentation and 9) additive and interactive effect of threats to internal validity (Shadish, Cook, & Campbell, 2002).

Ambiguous temporal precedence indicates a lack of clarity of variable occurrence, thereby influencing the cause and effect relation. In our research, temporal precedence occurs when variables in one of the twelve indicators are multi-interpretable. The only multi-interpretable variable in the defined formulas is the variable MC in the calculation of the DT-Indicator, DST-Indicator, DPT-Indicator and, DSPT-Indicator. To mitigate the temporal precedence, a procedure was defined and applied to determine if the MC variable should be 0 or 1. Learning, Selection, history, maturation, attrition, instrumentation and additive and interactive effects of threats to internal validity are excluded due to the experiment setup.

Outcomes of an experiment can vary when subjects, tasks or the environment changes. External validity is concerned with the extension of variations on such changes (Shadish et al., 2002). Our results were obtained from one organization and within that organization one decision service. Therefore, we cannot claim that our conclusions are generally applicable. However, the answer to the research question itself is not influenced by the fact that only one case (decision service) has been analyzed. Also, the decision service consisted out of 16 individual decisions, which increases the N for the decision-related measurements. Our experiment has been applied outside the project life cycle of the SSB. We do not consider this as a threat to environmental validity since the entire procedure can be repeated during normal project life cycles.

Conclusion and Further Research

Business decisions and business logic are an important part of an organization’s daily activities. In the not so near past they were modelled as integrative part of business processes, however, during the last years, they are managed as a separate entity. Still, decisions and underlying business logic often remain a black box. Therefore, the call for transparency increases. In current literature, frameworks to measure the transparency of decisions are predominantly focused on tactical and strategic decisions. Therefore, we addressed the following research question for this study: “*How can the transparency of an operational decision be quantitatively evaluated?”*

We presented a decision transparency framework including 12 indicators, namely: DT-Indicator, DST-Indicator, DPT-Indicator, DSPT-Indicator, DET-Indicator, DSET-Indicator, BLS-Indicator, and BSLS-Indicator, DDT-Indicator, DSDT-Indicator, DQT-Indicator and DSQT-Indicator. Each measurement calculates a specific type of transparency for operational decisions. By means of an experiment, based on case study data from a governmental institution, we have shown the applicability of the model. Results show that the measurements are useful and applicable in practice. However, evaluation of the measurements has indicated some room for improvement. In future research, we aim to incorporate these changes into the formulas. Furthermore, future research should also focus on further validating the framework presented in this paper using more cases, and ideally, cases from different industries in various sizes to improve its generalizability.

From a practical perspective, our study provides lawyers, business rules modellers and (business) decision modellers with a framework that can be used to indicate the transparency they provide in practice. This will enable organizations to provide insights into the cooperation with law and set the path to the desired transparency. For example, with the arrival of the GDPR regulation in May 2018 (European Union, 2016a), this is a prerequisite.

References

Blenko, M. W., Mankins, M. C., & Rogers, P. (2010). The Decision-Driven Organization. *Harvard Business Review*, *88*(6), 54–62. Retrieved from https://hbr.org/2010/06/the-decision-driven-organization

Boyer, J., & Mili, H. (2011). *Agile business rule development: Process, Architecture and JRules Examples.* Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-642-19041-4

Brandsma, G. J., & Schillemans, T. (2012). The accountability cube: measuring accountability. *Journal of Public Administration Research and Theory*, *23*(4), 953–975.

Chen, H., Chiang, R. H., & Storey, V. C. (2010). Business intelligence research. *MIS Quarterly*, *34*(1), 201–203.

Debevoise, T., Taylor, J., Sinur, J., & Geneva, R. (2014). *The MicroGuide to Process and Decision Modeling in BPMN/DMN: Building More Effective Processes by Integrating Process Modeling with Decision Modeling*. CreateSpace Independent Publishing Platform.

Drew, C. H., & Nyerges, T. L. (2004). Transparency of environmental decision making: A case study of soil cleanup inside the Hanford 100 area. *Journal of Risk Research*, *7*(1), 33–71.

European Union. (2016a). GDPR Portal: Overview. Retrieved December 1, 2017, from http://www.eugdpr.org/

European Union. (2016b). REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. *Official Journal of the European Union*, *119*(1), 1–88.

Grimmelikhuijsen, S. G., & Welch, E. W. (2012). Developing and Testing a Theoretical Framework for Computer-Mediated Transparency of Local Governments. *Public Administration Review*, *78*(1), 562–571.

Hay, D., Healy, K. A., & Hall, J. (2000). Defining business rules-what are they really. *The Business Rules Group*, 400.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Morgan, T. (2002). *Business rules and information systems: aligning IT with business goals*. Addison-Wesley Professional.

Nelson, M. L., Rariden, R. L., & Sen, R. (2008). A lifecycle approach towards business rules management. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences* (pp. 113–123). IEEE.

Nelson, M. L., & Sen, R. (2014). Business rules management in healthcare: A lifecycle approach. *Decision Support Systems*, *57*, 387–394. http://doi.org/10.1016/j.dss.2012.10.044

Object Management Group. (2016a). *ArchiMate® 3.0 Specification*. Retrieved from http://pubs.opengroup.org/architecture/archimate3-doc/

Object Management Group. (2016b). *Decision Model And Notation (DMN), Version 1.1*. Retrieved from http://www.omg.org/spec/DMN/1.1

Raynolds, L. T. (2009). Mainstreaming fair trade coffee: from partnership to traceability. *World Development*, *37*(6), 1083–1093.

Rogers, P., & Blenko, M. (2006). Who has the D? *Harvard Business Review*, *84*(1), 52–61.

Schlosser, S., Baghi, E., Otto, B., & Oesterle, H. (2014). Toward a functional reference model for business rules management. In *the 47th Hawaii International Conference on System Sciences (HICSS)* (pp. 3837–3846). IEEE.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Wadsworth Cengage learning.

Smit, K. (2018). *Organization and Governance of Business Rules Management Capabilities*. Open University the Netherlands.

Smit, K., Versendaal, J., & Zoet, M. (2017). Identifying Challenges in BRM Implementations Regarding the Verification and Validation Capabilities at Governmental Institutions. In *PACIS 2017 Proceedings*. Langkawi, Malaysia: Association for Information Systems (AISeL).

Smit, K., & Zoet, M. (2018). Identifying Challenges in Business Rules Management Implementations Regarding the Governance Capability at Governmental Institutions. In *Proceedings of the 51st Hawaii International Conference on System Sciences* (pp. 2383–2392). Waikoloa (HI), United States: IEEE.

Smit, K., Zoet, M., & Versendaal, J. (2018). Challenges in the Implementation of the Elicitation, Design and Specification BRM capabilities. *Journal of Information Technology Theory and Application (JITTA)*, *18*(4).

van der Aalst, W. M. P., ter Hofstede, A. H. M., & Weske, M. (2003). Business Process Management: A Survey. In *International conference on business process management* (pp. 1–12). Springer Berlin Heidelberg.

Vanthienen, J. (2001). Ruling the business: about business rules and decision tables. In *New Directions in Software Engineering* (pp. 103–120).

Von Halle, B., & Goldberg, L. (2009). *The Decision Model: A Business Logic Framework Linking Business and Technology*. CRC Press.

Weske, M. (2012). Business process management architectures. In *Business Process Management* (pp. 333–371). Berlin, Heidelberg: Springer.

Zoet, M. (2014). *Methods and Concepts for Business Rules Management* (1st ed.). Utrecht: Hogeschool Utrecht.

Zoet, M., Ravesteyn, P., & Versendaal, J. (2011). A structured analysis of business rules representation languages : Defining a normalisation form. *Proceedings of the 22nd Australian Conference on Information Systems*, Paper 20.