Integrating BPMN with DMN to model complex Public Services: The case of Getting a Transportation Card for Disabled in Greece

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Abstract

The provision of high-quality Public Services (PSs) constitutes a core activity of the public sector. Consequently, PS modeling has received considerable attention. The Business Process Model and Notation (BPMN) is a standard often employed in PS modeling. BPMN diagrams are clear and understandable in the case of simple PSs. However, this is not true when modeling complex PSs i.e., those including a large number of versions. Different versions exist in a complex PS since, for example, different groups of citizens may have to submit different supporting documents with their application based on their financial or civil status. In those cases, the relevant BPMN diagrams often have numerous gateways thus becoming very complex, which hinders their applicability and usefulness. In the last few years, the Decision Model and Notation (DMN) has been introduced and its integration with BPMN is used for modeling complicated business processes in the private sector. However, its effectiveness has not been investigated in the case of complex PSs. The aim of this research is to investigate the benefits and challenges of modeling complex PSs using BPMN and DMN. For this purpose, the Greek PS "Getting a Transportation Card for Disabled" is analyzed and BPMN is used to model the PS in two different ways, one with and one without the use of DMN. The results suggest that DMN models provide useful insights into the different PS versions while BPMN diagrams become simpler and more understandable. On the other hand, the public sector needs to accommodate yet another modeling notation which increases the required human capital needed for PS modeling.

CCS CONCEPTS • Applied computing • Computers in other domains • Computing in government • E-government

Keywords: Public Service (PS), Business Process Model and Notation (BPMN), Decision Model and Notation (DMN), Transportation Card.

ACM Reference Format:

1 Introduction

The provision of high-quality Public Services (PSs) constitutes a core activity of the public sector. Therefore, PS modeling has received considerable attention. The BPMN is a standard often employed in modeling business processes in both the private and public sector. The outcome is meant to be a clear and comprehensible diagram, which is useful for improving the operation of the depicted process. PS provision can be perceived as a process, having a clear goal, participants, and a number of steps. Consequently, BPMN has been extensively used in the public sector to model PS provision. The resulting BPMN diagram has a beneficial impact on PS management [17, 18]. The impact is evident in the case of simple PSs where the resulting BPMN diagrams are simple and understandable.

In reality however, a large number of PSs are actually complex i.e., they include a large number of versions. Different versions exist in a complex PS since, for example, different groups of citizens may have to submit different supporting documents with their application based on their financial or civil status. In those cases, the resulting BPMN model has to accommodate all different versions of the depicted PS. Consequently, the resulting BPMN diagram of a complex PS often have numerous gateways thus becoming very complex, which hinders their applicability and usefulness. As a result, the scientific community suggested that BPMN displays an inability to model complicated business processes in a simplistic way, due to the decision logic that is required [10].

In the last few years, the Decision Model and Notation (DMN) has been introduced to model the decision-making process [7]. The integration of BPMN with DMN is used in modeling business processes in the private sector. Instead of creating complicated models to depict the decision logic behind an action, the standardization of DMN leads to the simplification of those models [14]. Thus, DMN makes the models of complicated processes simpler and more useful. Despite these advantages however, the integration of BPMN with DMN has not been investigated by the scientific community in the case of complex PSs.

[1]* Place the footnote text for the author (if applicable) here.

The aim of this research is to investigate the benefits and challenges of modeling complex PSs using BPMN and DMN. For this purpose, this paper uses as a case study the Greek PS "Getting a Transportation Card for Disabled in Greece". This PS has different versions depending on citizens' profile. BPMN is employed to model the PS in two different ways, one with and another without the use of DMN, in order to investigate the effect of employing DMN.

The rest of this paper is structured as follows. Section 2 provides essential background work related to the fundamental elements of BPMN, DMN, their integration, and the current use of BPMN in public sector. Section 3 outlines the methodology followed, while section 4 describes the results. Finally, section 5 exhibits the conclusions and the potential for future work.

2 Background Work

This section presents background material on BPMN, DMN, their integration, and the current use of BPMN in the public sector.

2.1 Business Process Model and Notation (BPMN)

Business Process Model and Notation (BPMN) was first introduced in 2004 by the Business Process Modeling Initiative (BPMI) and since 2006, adopted by Object Management Group (OMG). It is considered as the *de facto* notation for modeling business processes in the private sector [2]. An important factor of the establishment of BPMN is its capability to facilitate a common understanding between stakeholders. In other words, BPMN bridges the gap between various stakeholders from process participants and process analysts to process engineers [1]. Figure 1 depicts the main elements of BPMN.

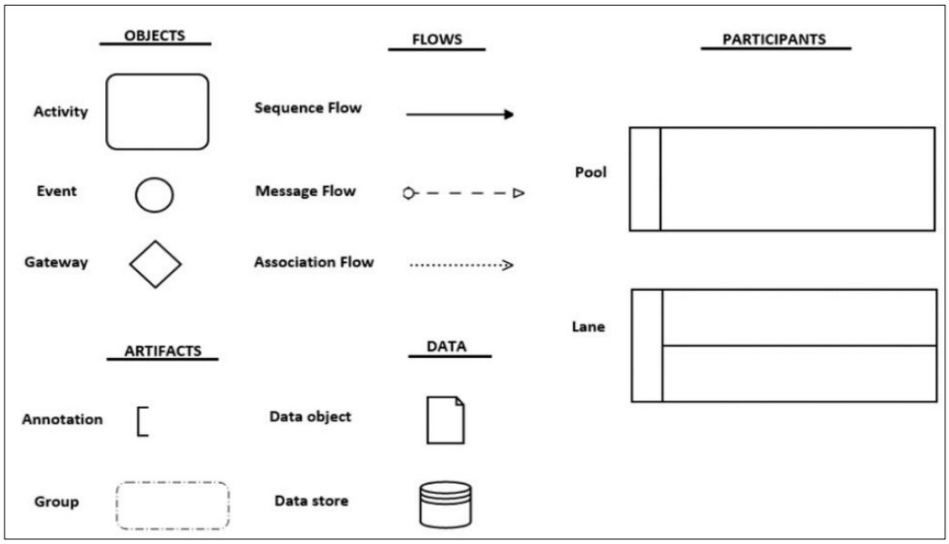


Figure 1: BPMN elements [1]

BPMN is considered as the ideal notation to model public services because it gives the ability to depict the interactions between business entities [6]. More specifically, diagrams can show the messages that are exchanged during an operation between participants. In this way they constitute a collaboration model, in which each participant acts as a collaborator for achieving a desired goal, just like in PS provision.

2.2 BPMN in the public sector

The European Union member states and other governments, having realized the importance and usefulness of PS modeling, suggested the standardization of BPMN for modeling processes in the public sector. The related endeavors and research displayed the beneficial impact that the use of BPMN can have on the operation of the public sector [16, 17, 18]. More specifically, a BPMN diagram offers transparency between related participants and their interactions [17]. In this way the acquisition of a deep understanding of the dependencies and the interactions between the related entities is achieved. Hence, better monitoring and control over a process is ensured. Combining all the above, it turns feasible to redesign the modeled PS with a view to improve its performance, increasing its effectiveness and efficiency and decreasing the demands

in cost and time [18, 20]. Additionally, the redesign of a PS makes reachable the concept of creating a proactive service, with a view to a more personalized and high-quality public sector [16].

2.3 Decision Model and Notation (DMN)

BPMN models become complicated and confusing when they have to depict the decision–making process [3]. As a result, experts started to treat the decision–making process as a separate concern, despite the fact that it is an integrated element of an organizational operation [4]. In 2015, OMG presented the Decision Model and Notation (DMN) as a way to apply decision logic into a BPMN model.

A DMN model consists of two levels, namely *the decision logic level* and *the decision requirements level*, which are interdependent. The former can be depicted as a decision table and describes the logic that leads to a specific decision. It consists of a number of input and output cells, which refer to the conditions that lead to a particular outcome. The latter describes the required information in order to reach a decision and its modeling can be done with one or more Decision Requirements Diagrams (DRDs) [5].

The decision requirements level of a DMN model concerns the Decision Requirements Graph (DRG), which exhibits the relation between the different elements of the model, for instance decision tables or input values [8]. For this purpose, utilizing a Decision Requirements Diagram (DRD) provides stakeholders with a clear view of the model and its interrelationships. Figure 2 illustrates the basic DRD elements.

Component		Description	Notation
Elements	Decision	A decision denotes the act of determining an output from a number of inputs, using decision logic which may reference one or more business knowledge models.	Decision
	Business Knowledge Model	A business knowledge model denotes a function encapsulating business knowledge, e.g., as business rules, a decision table, or an analytic model.	Business knowledge
	Input Data	An input data element denotes information used as an input by one or more decisions. When enclosed within a knowledge model, it denotes the parameters to the knowledge model.	Input data
	Knowledge Source	A knowledge source denotes an authority for a business knowledge model or decision.	Knowledge source
Requirements	Information Requirement	An information requirement denotes input data or a decision output being used as one of the inputs of a decision.	
	Knowledge Requirement	A knowledge requirement denotes the invocation of a business knowledge model.	
	Authority Requirement	An authority requirement denotes the dependence of a DRD element on another DRD element that acts as a source of guidance or knowledge.	
Artifacts	Text Annotation	A Text Annotation consists of a square bracket followed by modeler-entered explanatory text or comment.	Text annotation

Figure 2: Basic DRD elements [7]

A decision table consists of a set of conditions that corresponds to the input values and a set of values that corresponds to the output cells. For a given set of input values, the matching rule (or rules) indicates the resulting value of the output variable [7]. The number of the returned outputs is related to the selected hit policy. A hit policy indicator provides the result of a decision table if multiple rules concurrently match [9].

2.4 BPMN and DMN integration

Treating business process and decision logic as separate concerns has a plethora of benefits on the final model. The main advantage is the application of the decision logic into the final BPMN diagrams via DMN models. This makes the final model more understandable since it consists of simpler BPMN and DMN models. In this way, the potential to simplify the depicted process is created. As diagram's complexity is decreasing, the processes of monitoring and redesign parts of the depicted process are facilitated. Furthermore, another outcome is the agility and flexibility of each BPMN and DMN model. Considering that these models have their own consistency, since in order to understand one of them it is not necessary to have an insight into the others [21], in some cases, that outcome can facilitate the reusability of the decision logic of a model [15].

Generally, there are five principles for process–decision modeling (5PDM) that promote a common guidance to create a consistent model based on decision logic [10]. These are:

- Include *all necessary decision outcomes* in the process flow
- Exclude *decision logic* and cascading XOR – splits from the process
- Include only *subdecisions* that directly influence the process
    i. Include *subdecisions* whose results are used in the process
    ii. Include *subdecisions* that affect the process control flow
    iii. Exclude *subdecisions* that are irrelevant to the process
- Include *decision hierarchy* in decision activity modeling
- Include *input data and intermediate results* for decision enactment

3 Methodology

The methodology followed to conduct this research includes four steps.

Step 1: Analyse the Greek PS "Getting a Transportation Card": In this step, the Greek PS "Getting a Transportation Card" is analyzed. This is an essential step in order to identify the phases of the PS and what actions the public servants should do to create the Transportation Card.

Step 2: Develop BPMN model for the PS without the use of DMN: In this step, the Greek PS "Getting a Transportation Card" is modeled in BPMN without using DMN models to handle the required decision logic.

Step 3: Develop BPMN model for the PS with the use of DMN: In this step, the Greek PS "Getting a Transportation Card" is modeled in BPMN and DMN. The decision logic is depicted with the use of DMN in order to create a more simplistic and comprehensible model.

Step 4: Analyse the impact of implementing DMN in a BPMN model on the public sector: In this step, a comparison between the two models is performed. This focus on identifying benefits and challenges of BPMN-DMN integration to model complex PSs.

4 Results

4.1 Analyse the Greek PS "Getting a Transportation Card"

In the last few years, the Greek government allows low-income, disabled Greek citizens to obtain a Transportation Card, as a way to support their inclusion and facilitate their daily transportation. This PS consists of three phases. Initially, stakeholders gather the appropriate evidence (mainly documents on their health and financial conditions) and submit their application. Then, public servants check the eligibility of the applicant and the completeness of the submitted supporting documents. Finally, they create the Transportation Card (or Cards) that each beneficiary is entitled to. For simplicity, we limit our scope to analysing and developing a model only for the third phase, the card's creation stage, not for all the phases of the PS. That phase refers to the creation of the related category card and a companion card if the applicant is eligible for one.

Two card categories can be distinguished, depending on, mainly, economic factors. Category one card entitles beneficiaries to a 50% discount on all Greek long-distance (inter-city) bus tickets. Category two card entitles beneficiaries, in addition to the benefits of category one, also to free transportation with the urban buses of their permanent residence.

Beneficiaries are entitled to a category two card, when (i) they have a personal annual income less than 23,000 € or (ii) they have a family annual income less than 29,000 € (for more dependent members with disability percentage greater than 67%, the limit is increased by 5,600 € for each member) or (iii) they are blind.

Furthermore, if applicants satisfy one of the following requirements, they are entitled to a companion card:

- Sight disability percentage greater than 80%
- Intelligence Quotient (IQ) less than 30
- Intellectual disability percentage greater than 80%
- Diffuse developmental disorders percentage greater than 80%

4.2 Develop BPMN model for the PS without the use of DMN

In the card's creation phase, decision logic is required in order to define the number and type of cards that each applicant is eligible. More specifically, the card creation phase requires three decisions as shown in Figure 3. Firstly, public servants should define which category card they have to create, based, mainly, on applicant's financial status. Secondly, public servants have to decide whether to create a category two card for the related beneficiaries, based on the evidence that applicants submitted with their application. Finally, the third decision refers to the companion card. Public servants check the kind and the percentage of the disability and determine if the applicants are also entitled to a Transportation Card for their companions. The required decisions are grouped in three different groups in the BPMN diagram, in order to display the points that are related to the decision–making process.

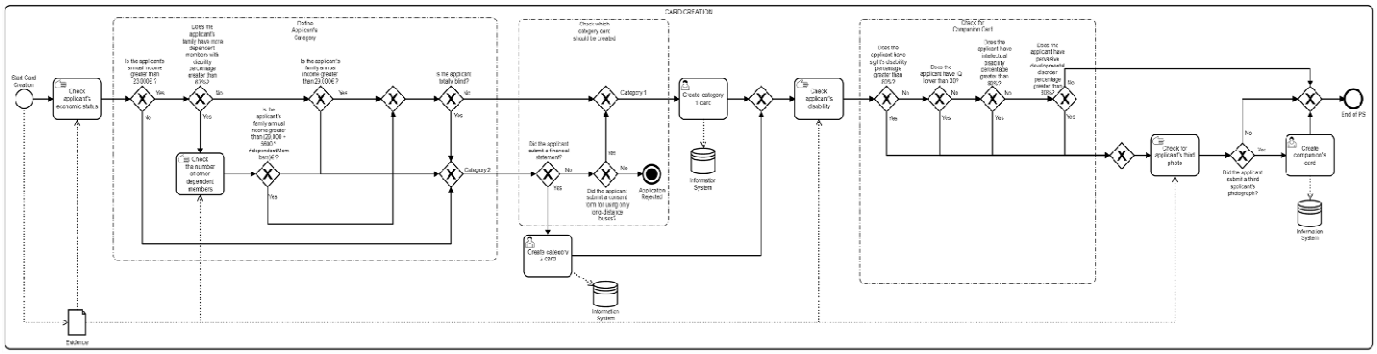


Figure 3: Card Creation BPMN diagram (without DMN)

4.3 Develop BPMN model for the PS with the use of DMN

The steps to simplify the BPMN diagram of Figure 3 is to identify the necessary decisions, which are already grouped, externalize them in DMN models and implement them into the BPMN model via the BPMN business rule tasks. In this regard, the following set of figures presents the DMN models that will replace each group with gateways related to the decision-making process.

Decision one (Figure 4) refers to the definition of the category card that each applicant is entitled to. For the creation of the related decision table, which checks whether the family annual income is greater than the defined limit (Figure 5), we took for granted that a family cannot have more than nine dependent members with a disability percentage greater than 67%. The selected hit policy is the *Unique hit police* since the rules cannot overlap each other and only one rule can match each time. The second decision table of the DRD diagram (Figure 6) that is related to decision one (Figure 5), controls the applicant's economic status and whether they are blind. Based on that information, it determines the category card that they are entitled to. It employs the *First hit policy* because rules can overlap, but the outcome remains the same for each of them. Namely, rules one to three can provoke an overlap, as each checks only one out of the three conditions. For example, an applicant can have a personal annual income less than 27,000 and be blind too. The result in all of them is that the applicant is eligible for a category two card.

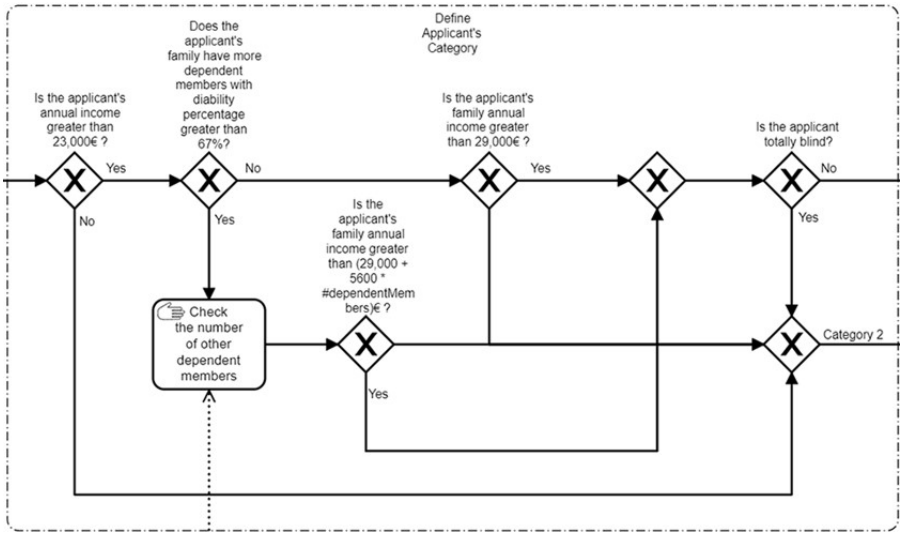
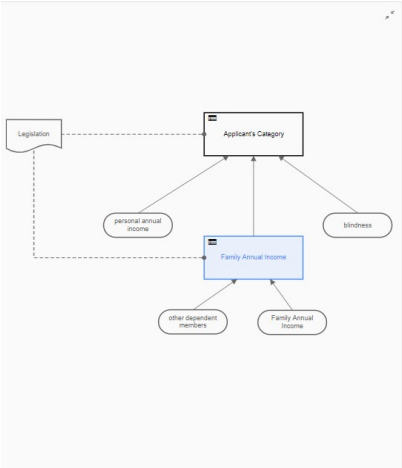


Figure 4: Decision 1



Family Annual Income — Hit Policy: Unique

	When	And	Then
	Dependent Members (integer)	Family Annual Income Limit (integer)	Family Annual Income (boolean)
1	0	<= 29000	true
2	0	> 29000	false
3	1	<= 34600	true
4	1	> 34600	false
5	2	<= 40200	true
6	2	> 40200	false
7	3	<= 45800	true
8	3	> 45800	false
9	4	<= 51400	true
10	4	> 51400	false
11	5	<= 57000	true
12	5	> 57000	false
13	6	<= 62600	true
14	6	> 62600	false
15	7	<= 68200	true
16	7	> 68200	false
17	8	<= 73800	true
18	8	> 73800	false
19	9	<= 79400	true
20	9	> 79400	false

Figure 5: DMN model of decision 1 (Family Annual Income decision table)

Applicant's Category | Hit Policy: First

	When	And	And	Then
	personal annual income (integer)	family annual income (boolean)	blindness (boolean)	Category (1 or 2) (integer)
1	<= 23000	-	-	2
2	-	true	-	2
3	-	-	true	2
4	> 23000	false	false	1

Figure 6: DMN model of decision 1 (Applicant's Category decision table)

Decision two (Figure 7) is referred to the submitted supporting documents which determine whether the related beneficiaries are entitled to a category two card. The decision table that checks the submitted evidence (Figure 8) applies the *Unique hit policy* as rules cannot overlap. It returns a set of values, one *integer* for the category card that will be created and one *boolean* to check whether public servants have to reject stakeholder's application. So, if applicants submitted one of the two required supporting documents the decision table returns the category of the Transportation Card that they are eligible for. Otherwise, the variable "rejection" becomes true and the card creation process is cancelled.

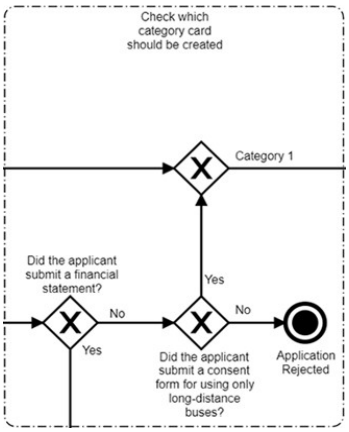
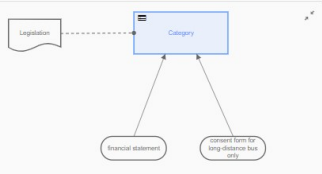


Figure 7: Decision 2



Category | Hit Policy: Unique

	When	And	Then	And
	financial statement (boolean)	consent form for long-distance bus (boolean)	category (integer)	rejection (boolean)
1	true	-	2	false
2	false	true	1	false
3	false	false	-	true

Figure 8: DMN model of decision 2

Decision three (Figure 9) refers to the provision of a Transportation Card for applicants' companions. In the corresponding decision table (Figure 10) the first four rules may overlap. For example, if a disabled person displays a percentage of sight disability greater than 80% and IQ less than 30, then both rule one and rule two match. For this purpose, the related decision table implements the *First hit policy*.

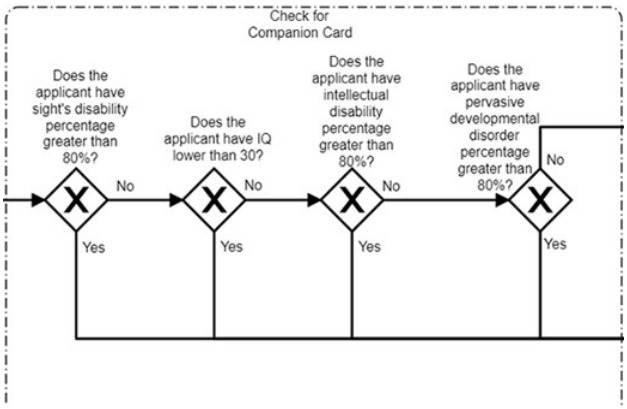


Figure 9: Decision 3

Figure 10: DMN model of decision 3

Having identified and externalized the required decisions to separate DMN models, Figure 11 presents the final model that was created using the integration of BPMN with DMN notation.

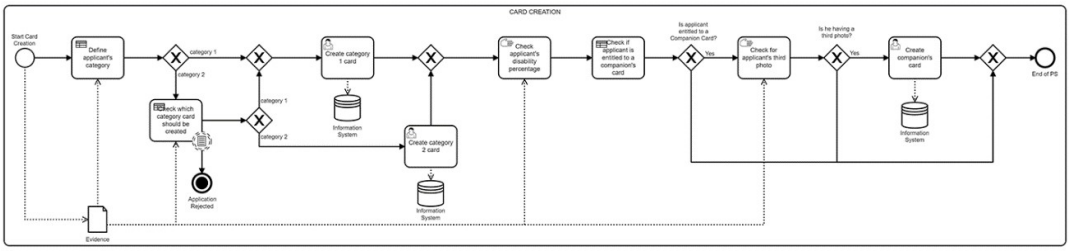


Figure 11: Final BPMN-DMN diagram

4.4 Analyse the impact of implementing DMN in a BPMN model on the public sector

The integration of DMN into BPMN diagrams has a number of benefits in the operation of the public sector. Firstly, the absence of DMN from a BPMN diagram that requires decision logic decreases significantly the diagram's complexity. For example, the diagram without the use of DMN consists of eighteen gateways, while the model that implements DMN has only seven. It is noticeable that the second diagram is simpler and more comprehensible than the first one. Additionally, the use of the decision tables makes clear the decision logic that provokes a specific outcome. This can lead to the enhancement of public servants' performance. More specifically, decision tables can be used to provide a clear insight into the legislation that defines their actions, avoiding in this way misunderstandings of the legislation. Furthermore, the final PS model provides the incoming public employees with an unambiguous image of their duties. Ultimately, the implementation of DMN into a BPMN diagram is useful for the development of Information Systems for PS provision. For example, a DMN model can facilitate the understanding of the necessary supporting documents for every different version of a complex PS. In this context, that information can be used for many different purposes, including, for example, the creation of a chatbot to inform stakeholders about the required evidence that they have to submit with their application. Hence, the quality of the PS provision will be improved.

On the other hand, the process of developing a BPMN diagram implementing DMN raises some challenges. In order to understand and develop BPMN-DMN diagrams for PS provision, public servants should have an appropriate background on the basics of DMN. Therefore, the expectations for public servants' knowledge level are increased, as they are responsible

to comprehend those diagrams. Moreover, to create a precise DMN model requires a deep understanding of the PS, the legislation and the different PS versions that might exist due to the decision logic. This constitutes a time–consuming process, however eventually the construction of the diagram will demand less effort.

5 Conclusions and Future Work

The aim of this paper was to investigate the use of the integration of BPMN with DMN for modeling complex PSs. For this purpose, the Greek PS "Getting a Transportation Card" is analysed and modeled in two different BPMN models, one with the exclusive use of BPMN and another one with the use of BPMN and DMN. The results of this research suggest that when referring to modeling complex PSs having many versions, the use of BPMN alone seems inadequate. The use of DMN can provide a solution. This is mainly due to DMN's ability to model decision logic in a simple manner. Hence, the objective of developing a simpler diagram is achieved, which contributes to the design of a more personalised and citizen–oriented public sector. However, there are still significant challenges to overcome before BPMN and DMN are institutionalized for PS modeling. For instance, the comprehension of a BPMN model is still a demanding task for public servants, which can reduce the value of the BPMN-DMN PS diagram.

We should further note that, despite the promising results, the research presented in this paper has a number of limitations. First of all, we focused on only one phase of one PS. Thus, there is a clear need for modelling additional PSs and gather more empirical data before reaching a definite conclusion on the advantages of employing DMN in BPMN modeling of PS provision. Future work also includes the evaluation of the final model. In particular, we aim to present the model to the responsible public servants in order to get feedback and conclude if such a model will be accepted by public servants and it will be beneficial for the public sector in general.

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