Modeling business processes: from a BPMN structured process flow to a declarative rule-based ACM method

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Abstract

In the current era of digital transformation, traditional business process management (BPM) often lack the flexibility required to manage dynamic and knowledge-intensive business processes. The purpose of this article is to present the possibilities of overcoming the limitations of traditional business process modeling focused on designing and representing the exact process flow by comparing two approaches: the widely adopted Business Process Modeling and Notation (BPMN) and the declarative, rule-based Adaptive Case Management (ACM) approach. Using a Repair Service Management (RSM) case study, we systematically analyze the strengths and limitations of both approaches regarding expressiveness, adaptability, and change management efficiency. While modeling using ad hoc subprocesses in BPMN offers some flexibility in modeling the flow of a business process, the declarative rule-based method empowers business experts to design and maintain business applications with a focus on the purpose and outcome of the business process rather than on designing its exact flow which is important to handle unforeseen situations. Building on these insights, we offer initial advice to help practitioners and researchers decide when to consider each modeling approach in dynamic business environments, contributing to the ongoing development of BPM methodologies that are essential for the digital transformation of companies.

Keywords: Adaptive Case Management, Dynamic Business Process Management, Business rules, Business Ontology, Business architecture, Value streams, Digital transformation

1 Introduction and related work

Business process management (BPM) is a well-established methodology for managing the lifecycle of activities in organizations [1]. Scientific Management is considered the precursor of BPM, focused on structured and repetitive mass production processes. Since then, BPM has covered all business processes of organizations, regardless of their nature or place in the value chain [2]. With the growing demand for product and service customization in the digital era, organizations increasingly require dynamic, knowledge-driven process management rather than rigid workflows [3–5]. Therefore, in the modern economy, where knowledge is the most competitive asset, restricting knowledge workers (employees who produce value due to their expertise) to operate strictly in accordance with pre-defined standard process flow models results in a *de facto* loss of the use of a significant part of the organization's intellectual capital [6].

Well-established approaches such as Adaptive Case Management (ACM) [7] or Dynamic BPM [2], overcome such limitations by considering the business goals to drive the unpredictable process and create actions at runtime constrained by rules, rather than following an exact flow of predefined actions. To implement the ACM paradigm, various modeling variants have emerged. The Case Management Model and Notation (CMMN), standardized by the Object Management Group (OMG), is the most widely recognized notation for explicitly modeling cases. CMMN allows for the definition of tasks, milestones, and events within a case, enabling flexible execution paths based on real-time context and decisions [8]. Additionally, declarative approaches such as Dynamic Condition Response (DCR) graphs prioritize defining constraints and business rules to govern activity execution, offering a robust framework for managing process variability without enforcing a strict sequential order [9]. Complementing these approaches, Gutiérrez et al. [10] propose a method that integrates business architecture principles with domain-specific ontology for ACM modeling. This approach leverages the structured ontology to capture the complete value stream, including its goals, activities, and business rules, using a formalized natural business language. This direct business-level definition allows for the instant enactment of the business information model, enabling agile adaptation and ensuring case compliance by guiding knowledge workers with transparently formulated rules.

Previous research [11–13] has examined structured and unstructured processes separately, but comparative studies evaluating BPMN and declarative models in real-world implementation contexts remain limited. Zensen et al. conducted a practical case study comparing BPMN's flexible ad hoc subprocesses with CMMN, demonstrating that CMMN offers a more native and clearer approach for highly flexible processes, albeit with increased modeling complexity [14]. However, their findings are confined to a single case. While their study focused on CMMN, the present study broadens the investigation by exploring a declarative rule-based ACM approach to address this gap, guided by the following research question:

What are the advantages and disadvantages of using a BPMN modeling method versus a declarative rule-based modeling method with ACM?

To answer this question, we model a Repair Service Management (RSM) case study using:

- Business Process Modeling Notation version 2 (BPMN), which enforces a structured process flow [15].
- A declarative, rule-based approach, which avoids predefined sequence of actions, leveraging values streams (from business architecture) and business ontology to model the business data objects [10].

Our comparative analysis examines the impact of each approach on workload, flexibility, and user experience, providing practical insights for BPM practitioners and researchers. This work evaluates how each method addresses the limitations of traditional BPM, particularly rigidity and adherence to predefined workflows, making it a valuable case study [16, 17]. This comparative analysis helps in understanding which method is better suited for certain types of processing and organizational contexts. As noted earlier, due to the importance of processes requiring dynamic management, developing a methodology for their effective modeling is of paramount importance [18]. We discuss the advantages and weaknesses of the two methods from modeling to execution.

The remaining of the article outlines the research methodology, describes and contrasts the two modeling methods, details a Repair Service Management use case and its implementation in both methods, followed by the discussion and conclusion.

2 Research methodology

The article uses an illustrative case study methodology [17] to present the modeling method and then to comparatively evaluate two different business process modeling approaches: structured process modeling using BPMN and declarative rule-based modeling using ACM. The case study method provides the reader with descriptive details that are important to support the research process and understand the results [19]. It should be emphasized that such publications are surprisingly rare, considering the importance of unstructured processes in the modern economy [5, 20].

To evaluate and compare business process design and execution methodologies, we adopted five key dimensions, each grounded in well-established frameworks from the BPM literature:

Modeling complexity. The effort required to define the process using each method[21].
Execution flexibility. The ability to adapt to unforeseen circumstances and process variations [22].
IT dependency. The level of technical expertise needed to implement the model [23, 24].
Knowledge worker autonomy. The degree of control that end users have on process execution [7].
Efficiency in change management. How easily processes can be adapted over time [23].

The selection of these five dimensions is motivated by their relevance to the core challenges and distinctions between highly structured (like BPMN) and flexible, adaptive (like declarative ACM) process management approaches, especially within dynamic real-world operational contexts.

The case study is based on Repair Service Management (RSM), a process within the Facility Management industry. The following steps are conducted (i) Modeling Phase – The RSM process was modeled in both BPMN and ACM, following best practices for each methodology. (ii) Implementation & Execution – Each model was simulated in an appropriate system to understand practical implications, (iii) Evaluation & Analysis – The models were compared using the evaluation criteria listed above. The authors of this paper are involved in the case study modeling in two roles: as researchers, bringing expertise in modeling techniques from both approaches, and as practitioners, providing insights into real-world practices to ensure the model's relevance.

Findings from the case study will be presented in the discussion section, where the strengths and weaknesses of each approach are analyzed in relation to the evaluation criteria. Each criterion will be analyzed through qualitative assessment and empirical insights from the case study implementation. Consistent with the nature of qualitative case studies, this analysis is largely interpretive, reflecting the accumulated perspectives and insights of the experts involved in and observing the process over time, among whom the authors served in both research and practical roles.

The applied illustrative case study method allows for the preparation of an objective result of the comparison of the usability of both approaches. The detailed conclusions resulting from this comparison can serve as guidelines for both researchers and practitioners who identify, improve, communicate and implement business processes requiring dynamic management.

3 Modeling methods

We consider two distinct approaches to model business processes. On one side, formal workflow notations like Business Process Model and Notation (BPMN) [1] provide a structured language for modeling complex workflows. BPMN's standardized graphical representation ensures a shared understanding among stakeholders, improving process transparency and consistency. Its machine-readable format enables automation, reducing manual effort, minimizing errors, and optimizing efficiency by streamlining repetitive tasks. On the other hand, Adaptive Case Management (ACM) models processes as a set of goals and rules that guide execution while ensuring compliance with business regulations [25]. ACM systems can integrate AI to learn from user actions and suggest the best next steps to achieve case goals in an optimal way [26].

Both approaches support business application development, designed by analysts and executed by knowledge workers. A typical business application consists of key components - data models, participants, actions, among others. In BPMN, these applications are process models, whereas in the discussed ACM methodology, they are value stream definitions.

3.1 Structured modeling with BPMN

For structured modeling, we consider BPMN 2.0, a well-known BPM modeling, which is well-suited for structured, predictable processes. This method defines strict task flows within process models, where different parties interact through message flows across distinct pools, with their roles represented as swimlanes within those pools. Processes rely on data objects that serve as inputs or outputs for tasks. Process execution adapts dynamically via conditional expressions (e.g., decision-making, scheduled tasks) visualized in a diagram as decision gates. Tasks or process fragments with an unpredictable course are modeled in BPMN using ad hoc subprocesses, which make it possible to determine, in the modeling phase, a list of tasks from which the process executor will be able to select, at his own discretion, the tasks for subsequent execution, as well as the conditions for completing the ad hoc subprocess. During the application design, experts define process models, and specify relevant data objects (artifacts). Additionally, data modeling involves platform-specific database definitions, requiring advanced IT knowledge during the design. Ultimately, the business application is only partially modeled in BPMN style [1, 6]. Complex decision making is commonly defined out of the scope of BPMN and requires integration with Decision Model systems.

3.2 Declarative modeling with ACM

ACM modeling is a declarative approach where business processes have no predefined flows [10, 27]. Instead of following a rigid workflow, knowledge workers have full flexibility to decide the next action based on the current situation. Compliance is enforced through business rules, preventing actions that violate regulations or policies. To support decision-making, machine learning algorithms analyze past case executions and suggest the best next action to achieve the case goal, ensuring value delivery to stakeholders [26].

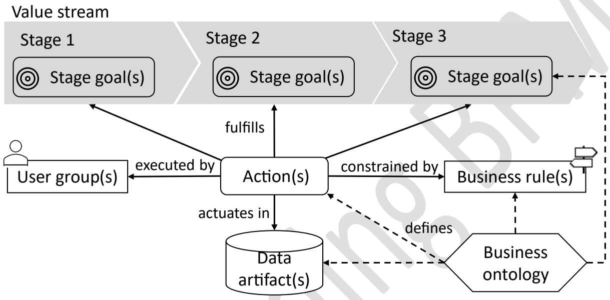

Figure 1. Main elements of the declarative rule-based ACM modeling.

Figure 1 illustrates the ACM modeling components in the design phase. Business applications are structured as value streams, supported by a business ontology that defines domain-specific concepts and relationships. Although the value stream imposes a certain flow, the presented ACM method allows any arbitrary stage goal to be completed even if “previous” stages are not closed. Actions and rules are expressed using business terminology, ensuring clarity, i.e. both use elements defined on the business ontology. The business rules within the ACM approach have different levels of enforcement, ranging from mandatory to advisory. This flexibility enables knowledge workers to override rules when necessary to ensure optimal case outcomes. Unlike traditional step-by-step process flow design, business experts using this approach focus on identifying and defining rules that guide actions toward achieving goals. As Ross [28] suggests, these rules are written in natural language using business vocabulary (from the business ontology) to ensure clarity for users. Thus, this declarative ACM approach combines a grammar with concepts and relations defined in the business ontology to create structured natural language rules that are human- and machine-readable [10]. All elements in the system – value streams, goals, actions and rules – are defined and implemented using an ontology. The ontology-driven approach simplifies modeling by standardizing elements and reducing redundancy. Supporting tools ensure consistency and automatic instantiation of concepts, facilitating updates without requiring IT intervention.

4 Business use case “Repair Service Management”

Repair Service Management (RSM) from the Facility Management industry was chosen as the case study due to its well-defined yet flexible nature, involving multiple interacting actors such as customers, service agents, technicians, and inventory managers. It follows a structured flow of tasks, events, and decision points but can also be modeled using a declarative approach, where execution is guided by constraints rather than a strict sequence (e.g., repair approval must precede invoicing, but other tasks can occur flexibly). RSM includes conditional flows (e.g., repair approved vs. rejected, spare parts available vs. ordering required) and maintenance services [29] which are a common field for process automation, leveraging BPMS, workflow engines, and declarative modeling techniques.

A RSM company specializes in repair and maintenance services for buildings, including electrical work, gardening, etc. The company’s front office manages customer requests and schedules work based on the customer's needs. The tasks involved in RSM include personnel assignments with the relevant skills, issues working orders and ensures working is performed according to the customer's requirements. Material orders may need to be approved before work starts, but in some cases, they can be handled in parallel. Role management is an important aspect, as supervisors must approve work requests before being executed.

With its comprehensive approach to repair and maintenance services, the RSM use case serves as a valuable model that can be easily transferred to other business areas. The following subsections present the design of a business application to implement RSM using (i) Structured process modeling method using BPMN 2.0 and (ii) declarative rule-based modeling using ACM.

4.1 BPMN modeling

For the Repair Service Management (RSM) use case, BPMN provides a standardized framework for designing the underlying business application. It allows us to visualize, define, and communicate the operational flows.

4.1.1 Business Process Model

Defining business process models is the first step in developing a business application with BPMN. We explicitly modeled the process flow, ensuring clear task sequences, predefined subprocesses, and decision gateways for process execution.

Figure 2 depicts a business process model for the RSM service. The process is initiated by a message start event, where the customer submits a request with details of their repair requirements. Within the RSM back-office pool, the clerk begins with the *Check Customer Request* task, evaluating the submitted details. The clerk team then assesses these requirements to assemble a team with the skills best suited to the needs. Based on the team composition and requirements, the clerk team prepares a Working Order (WO), which requires verification and approval by the RSM service supervisor. Each activity may involve subprocesses and interactions with customer processes, omitted here for brevity. The process concludes with the *Format Customer Letter* task, followed by a message event to notify the customer.

The WO may also specify required materials for the repair (an ad hoc subprocess). Once approved, the clerk team schedules the team members according to the plan in the WO and, if necessary, reserves the required materials. When both the team and materials are prepared, the WO can be submitted to the customer. Since material orders are optional and lack predefined details, they are modeled as an ad hoc subprocess with 2 tasks (*Order Material* and *Order Equipment*). In our model, materials are ordered before the WO is approved. This decision assumes that there is a low risk of work order rejection and that materials are commonly required, with the risk of unnecessary purchases. Alternative workflows, such as ordering materials *after* WO approval, could avoid unnecessary costs but introduce delays if approval takes time. Other workflows could also include preemptive booking personnel before WO approval. Both examples would require maintaining multiple models and updating existing ones, which carries the risk of inconsistency in ongoing case executions, increasing modeling complexity.

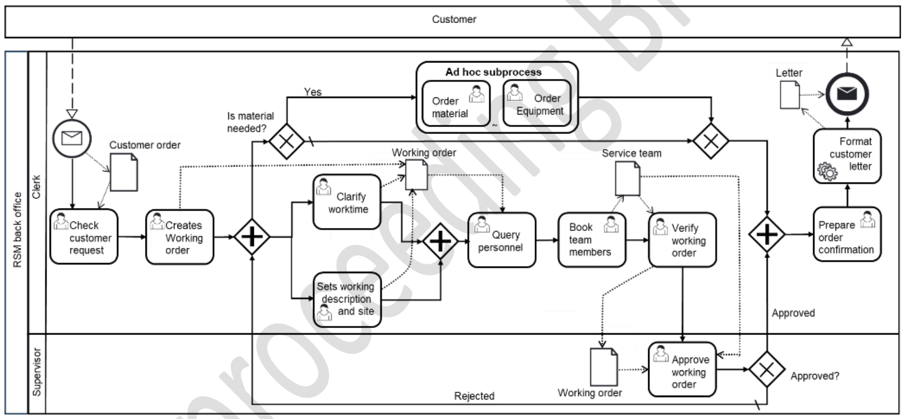

Figure 2. BPMN for Repair Service Management.

This process highlights the trade-offs between flexibility and complexity. A model designed for maximum flexibility would require numerous subprocess variations, making it complex and error-prone, whereas a simpler model would enforce a rigid execution, reducing adaptability [18].

4.1.2 Defining participants (roles)

The RSM application comprises two user groups, namely the *clerk group*, responsible for the customer-facing activities, and the *supervisor group*, responsible for approving certain activities. In the BPMN those are represented as swimlanes. While knowledge worker autonomy is moderate, as workers have some decision-making, their actions remain constrained by the process model. Supervisors provide oversight, particularly for WO approvals, ensuring that process execution maintains control over decisions.

4.1.3 Defining data content (artifacts)

The business application must read, create, or update data objects that reflect its execution state. Thus, the business administrator must determine during the design phase which data objects are relevant to store the case data. In RSM we identify four data objects: (i) **Customer order** (customer name, address, request description, etc.), (ii) **Working order** (working order data, namely the working site, description, etc.), (iii) **Service team** (assigned service team), and (iv) **Service confirmation letter** (file generated by the system and sent to the customer).

4.1.4 Modeling evaluation

Modeling complexity: Moderate to high, due to the balance between flexibility, process variations, and IT dependencies. Managing multiple models for alternative workflows increases complexity and maintenance efforts with the risk of inconsistencies.
Execution Flexibility: Highly dependent on model design. A highly flexible model introduces complexity and error-prone execution, while a simpler model enforces rigidity.
IT Dependency: High, as while BPMS is mainly focused on process modeling, the resulting artifacts still need to be structured and stored in a database, requiring, among others, database development skills.
Knowledge Worker Autonomy: Moderate. Workers (clerks and supervisors) can make decisions within their roles but remain bound to predefined workflows.
Efficiency in Change Management: A balance between flexibility and complexity. Modifying workflows (e.g., when to order materials or book personnel) requires either maintaining multiple models or updating existing ones, increasing the risk of inconsistencies.

4.2 ACM modeling

Building upon traditional ACM, we model the RSM with the enhanced ACM modeling approach that explicitly incorporates elements of business architecture (such as value streams), as described by Gutierrez et al.[27]. This enhancement allows us to structure a given business case into a value stream, where each stage has defined specific goals. Actions to reach the goals can be further constrained by business rules – ensuring a flexible, although business compliant workflow.

4.2.1 Value Stream definition

The *Repair service request* value stream (Figure 3) delivers the previously explained repair service to customers, structured into three stages: *Requirements defined*, *Service team determined* and *Working order submitted*. Unlike BPMN modeling, execution is not predefined—knowledge workers determine the best sequence of actions within constraints, providing flexibility. Moreover, if business rules allow it, the value stream does not need to be executed sequentially.

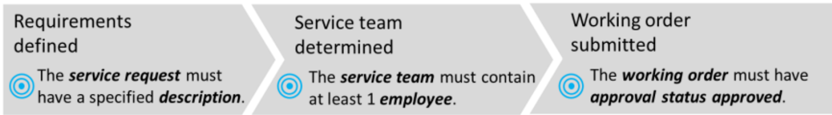

Figure 3. Repair service request value stream, stages and examples of stage goals.

4.2.2 Business ontology definition

The underlying ontology defines key business concepts, properties and their relationships. Figure 4 depicts an extract of the RSM ontology, including (i) concepts (e.g., service request, customer, employee) and (ii) properties of a concept connected with dashed arrows (e.g., *Name* of *customer*). Full arrows denote a relation between two concepts (e.g., *customer **places** service request*).

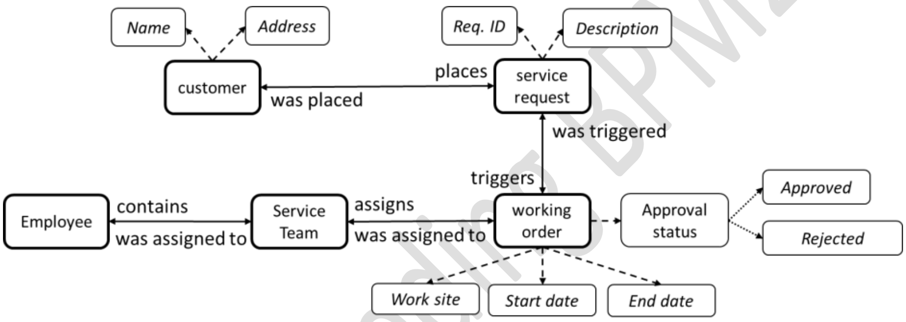

Figure 4. Extract of the business ontology used in the ACM modeling.

The ontology itself can be shared across an entire business domain (e.g., maintenance services), ensuring consistency and interoperability, while individual applications can be customized for specific use cases (e.g., repair maintenance services) or customers to meet operational needs.

4.2.3 Goals, actions and business rules

The declarative nature of the modeling encompasses defining goals for each stage, actions to achieve these goals, and establishing business rules to govern the execution of the value stream. These elements, including goals, actions, and rules, are derived from the business vocabulary entered in the business ontology.

Goals. Figure 3 also shows some of the goals defined for the stages of the *Repair service request* value stream. The business ontology concepts of *service request*, *service team* and *working order*, with their properties, are used to define the goals. Moreover, on the stage *Service team determined*, the relation *Service team contains Employee*, which is used to define a goal that at least one employee must be part of the service team.

Actions. The accomplishment of goals is done through the execution of actions, which are linked to an ontology business concept with an expression *verb* + *object*. The *verb* can include generic CRUD operations (*create*, *read*, *update*, *delete*) or domain-specific verbs such as *place*, *verify*, etc. The *object* is a business concept or a property on which the verb acts, e.g., *Places service request*. Implicitly, the *subject* of the action expression is the participant that executes the action based on the assigned roles.

Business rules. Business rules are written in a natural language style supported by a grammar that assists business experts in defining rules on actions. Rules combine elements from the business ontology (previously defined by the users) with grammar elements, such as must, have, etc., to create a structured natural language expression that is simultaneously readable by humans and unequivocally interpreted by the system. These rules are enforced when users attempt to start any actions (entry level) or when finalizing them (completion level). There are different enforcement levels, from mandatory rules to simple guidelines. For example, similarly to the discussion on BPMN modeling, if preparing the order confirmation requires that the equipment is ordered first, we could define a rule such as:

"To <u>prepare order confirmation</u>, the <u>working order</u> must have a specified <u>material</u>."

To modify this requirement, we would simply need to rewrite the business rule. Similarly, if a new regulation mandates that every working order must include a customer's phone number for contact purposes, this would require adding a new mandatory *Phone Number* property to the ***Customer*** concept and updating the business rules to ensure that all new service requests include a phone number before submission. The execution of actions can be restricted to different roles (e.g., *clerk* and *supervisor*), but we do not detail these constraints here for simplicity.

4.2.4 Modeling evaluation

Modeling complexity: Moderate to high, but it differs from traditional BPMN-based process models. Instead of relying on an explicit process flow, this approach dynamically manages business rules, constraints, and dependencies.
Execution Flexibility: High, enabling multiple valid paths to achieve goals but requiring careful rule management to avoid inconsistencies. AI agents, that learn from users in real time, can support knowledge workers to decide the next action.
IT Dependency: Low. Defining the ontology (information model) and the business rules in natural language reduces dramatically the IT dependency. IT has to configure interfaces for data services with core business systems during the initial setup.
Knowledge Worker Autonomy: High, allowing flexible decision-making within defined constraints.
Efficiency in Change Management: Moderate. Rules simplify updates, but complex interdependencies require careful governance.

5 Discussion

The RSM was implemented with both methods: *modeling in BPMN* and *ACM based modeling*, with focus on the four defined metrics—Modeling Complexity, Execution

Flexibility, IT Dependency, Knowledge Worker Autonomy and Efficiency in Change Management. In this section, we will evaluate both approaches and provide a comparative analysis, which are summarized in Table 1.

Modeling Complexity. Both approaches share moderate to high complexity. The *ACM modeling* introduces complexity in managing rules but offers greater flexibility in process execution and change dependencies with natural language.
Execution Flexibility. While both approaches support flexibility, *ACM modeling* provides a more inherent and consistent flexibility due to its dynamic rule-based model. *BPMN modeling*, in contrast, requires careful modeling to achieve similar flexibility, but at the cost of introducing many variants and potential errors and inconsistencies.
IT Dependency. *BPMN modeling* relies heavily on BPMS and requires database skills, making it more IT-dependent, while rule-based modeling offers greater flexibility in IT involvement. Although *ACM modeling* still requires a robust IT infrastructure for rule management, it is less reliant on rigid IT systems compared to BPMN modeling.
Knowledge Worker Autonomy. *ACM modeling* stands out in terms of worker autonomy. It enables a higher degree of decision-making power, allowing workers to navigate the process more independently. However, this autonomy may also lead to a loss of perspective or alignment with the overall goal if not carefully managed. In such cases, AI could be leveraged to provide real-time guidance and support. *BPMN modeling*, on the other hand, limits worker autonomy due to its rigid process structure, requiring workers to follow the predefined workflow with less freedom for process adaptation.
Efficiency in change management: In *BPMN modeling*, efficiency is constrained by the need to preserve structural integrity, requiring a balance between control and adaptability. In contrast, *ACM modeling* offers greater efficiency for frequent or small-scale changes due to its declarative nature. However, governance mechanisms must be robust to handle complexity and ensure consistency.

Table 1. Comparison Summary.

Metric	BPMN modeling	ACM modeling
Modeling complexity	Moderate to high; rigid process flow	Moderate to high; dynamic rule management
Execution flexibility	Low to moderate; dependent on model design; risk of errors	High; multiple valid paths, requires careful rule management
IT dependency	Moderate to high; requires database modeling for artifacts.	Low; natural language rule definition based on ontology modeling.
Knowledge worker Autonomy	Moderate; tied to workflow, supervised	High; empowered to make decisions within constraints
Efficiency in change management	Moderate; Process changes requires updating flows and dependencies.	Low; rule updates can be more agile, but complexity must be managed carefully.

Key Insights:

- Flexibility vs. rigid structure: rule-based modeling consistently offers more execution flexibility and worker autonomy compared to Structured process modeling. However, this flexibility comes with the challenge of managing business rules and avoiding inconsistencies.
- IT dependency: While both approaches require IT support, modeling in BPMN is more IT-dependent due to the BPMS and database design, while the ACM rule-based modeling relies on business domain specific ontologies; thus, requires only IT for initial data interface definitions.
- Worker autonomy: rule-based modeling clearly excels in terms of knowledge worker autonomy, offering a system that empowers workers to make decisions based on their expertise and understanding of the business rules, while structured process modeling retains more control over the workflow, limiting worker flexibility.

6 Conclusions

This work explores two distinct modeling methods: a structured process approach with BPMN and a declarative rule-based method with ACM. They differ in their underlying structure and execution flexibility. The BPMN modeling offers some flexibility during execution, allowing knowledge workers to incorporate optional tasks. This method is well-suited for organizations with predictable processes that have some dynamic elements.

In contrast, the ACM modeling method introduces a new paradigm for highly flexible workflows. This approach utilizes a value stream with stage goals and business rules to guide execution. ACM excels in highly dynamic business environments where real-time execution changes frequently and business application rules require frequent updates. In combination with an AI agent, flexibility can be leveraged by best next action suggestions to knowledge workers during run time execution.

The Repair Service Management case study illustrates these benefits in practice, offering concrete insights into how organizations can navigate ongoing change with greater agility and reduced dependency on rigid process structures. The choice between these two methods depends on the nature of the process and the specific needs of the organization. While BPMN modeling is ideal for organizations with processes entirely predictable or predictable with ad hoc exceptions, ACM model offers greater flexibility in organizations with highly dynamic workflows by enabling purpose-driven process execution.

Looking ahead, implementing ACM method may require additional training for experts due to the business ontology component. Future work could integrate a Large Language Model to assist with process modeling. Additionally, expanding this research to include typical use cases across different industries and utilizing the Business Process Nature Assessment Framework (BPNAF) [30] could provide valuable insights for selecting the optimal modeling methods for specific organizations.

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