Investigating the Role of Enterprise Architecture in Big Data Analytics Implementation: A Case Study in a Large Public Sector Organization

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Full research paper

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Abstract

Big Data Analytics (BDA) offers capabilities that can support a wide range of business areas across an organization. Organizations are increasingly turning to Enterprise Architecture (EA) to manage BDA implementation complexities. Through a case study in a large public sector organization, how EA supports various stages of BDA implementation is examined. The findings show that EA can address BDA challenges through 18 specific roles, which are categorised into four domains: Strategy (6 roles), Technology (4 roles), Collaboration (3 roles) and Governance (5 roles). While EA appears to have the most prominent role in strategy planning process, our study also identifies factors that can lead to the ineffectiveness of EA roles, such as frequent changes in business strategy. This study offers important implications to research and practice in EA and BDA implementation.

Keywords Big Data Analytics, Enterprise Architecture, BDA Strategy, BDA Governance

1 Introduction

The rise of big data analytics (BDA) has brought both benefits and challenges to business. Firms that employ BDA properly have the ability to sense and respond to market changes effectively and efficiently (Mikalef et al. 2021; Wamba et al. 2017; Gupta and George 2016). BDA has multidimensional capabilities that entails technological tools, structure mechanisms, and management practices based on enterprise system portfolios and data repositories, all of which are strategically designed to create business value (Dremel et al. 2017; Gupta and George 2016). However, the complexity of big data and the analytical methods underpinning BDA creates multiple challenges (Sivarajah et al. 2017). Firms often struggle to integrate BDA with their overall strategy (Mikalef et al. 2021; Grover et al. 2018), develop the necessary capabilities (Braganza et al. 2017), and understand the processes of BDA value creation (Grover et al. 2018; Wamba et al. 2017).

Leveraging BDA to its full potential requires the effective integration of BDA into the firm's processes and IT landscape. Enterprise Architecture (EA) can serve as a tool to manage complexities of BDA by providing a configurable landscape (Gong and Janssen 2021). EA is a collection of artifacts that describe various aspects of an enterprise from an integrated business and IT perspective. EA practice leverages these EA artifacts to improve decision-making and business-IT alignment (Kurnia et al. 2020). Scholars have recently started to examine how to improve the success rate of BDA adoption through EA practice, such as by guiding BDA transformation and employing EA artifacts to address stakeholder concerns (Burmeister et al. 2018; Vanauer et al. 2015). These artifacts include business model, roadmap, reference architectures, software tools, and BDA algorithm.

Despite its significance, there is a lack of empirical research on the role of EA in adopting new technologies like BDA (Gong and Janssen 2021; Rashed and Drews 2020; Burmeister et al. 2018). Lack of in-depth study related to EA and BDA integration impedes the possible roles that EA can play for BDA implementation. The role of enterprise architects is also evolving in response to organizational transformations (Strano and Rehmani 2007). To reap the benefits of BDA adoption, organizations must develop BDA capabilities and enforce effective governance (Mikalef et al. 2021; Wamba et al. 2017; Espinosa and Armour 2016). Since BDA activities span across the organization, coordination and governance mechanisms are necessary and must align with the organization's strategic goal (Espinosa & Armour, 2016). However, the configuration and orchestration of various EA resources to build BDA capabilities remain an immature field of study (Dremel et al. 2020; Wamba et al. 2017).

To address the above knowledge gaps, this study aims to analyse the role of EA in the adoption and implementation of BDA initiatives. It builds upon previous studies that integrate BDA and EA, by unfolding the transformation process and how EA practice guides BDA implementation. The research question proposed is: *What roles are played by EA in supporting BDA implementation?* The role of EA in integrating BDA into the existing architectural landscape is best studied in a large organization with complex business processes and IT landscapes that require coordination among various actors at different levels. Based on an in-depth case study with a large government organization, the study identifies 18 specific roles through which EA practice supports BDA implementation. Further, EA can be used in different ways to support BDA implementation, each requiring specific capabilities in strategy, technology, collaboration, and governance.

The paper is structured as follows. First, we review previous literature on possible EA roles in supporting BDA implementation. Then, we describe the research method and describe the case organization. Next, we explore various EA roles identified in the case study and discuss the findings. Finally, we conclude the paper and outline research limitations and potential future research.

2 Previous Literature on EA Roles for BDA Implementation

While there is a considerable body of literature on BDA and EA domains individually, only limited studies have explored the intersection of the two domains (Gong and Janssen 2021; Kehrer et al. 2016). Based on the analysis and synthesis of the existing literature on the use of EA in BDA implementation, we have identified 14 roles of EA to integrate BDA within the organizations (Adhytia et al. 2022). These roles are classified into four categories: *strategy technology, collaboration* and *governance-related support*.

In *strategy-related support*, EA plays four crucial roles in supporting BDA implementation. First, EA aligns BDA with enterprise strategy through architecture planning and development(Kehrer et al. 2016). This alignment is achieved by delivering architectural information, flexible infrastructure and common building blocks. Second, EA drives innovation of product and services, particularly through development of data-driven business models (Chen et al. 2017; Rashed and Drews 2020). Third, EA

enables BDA-related organization transformation and strategic planning through development of purposeful EA artifacts (Burmeister et al. 2018; Rashed and Drews 2020). EA provides a strategic planning for the transformation of firm's IT systems in response to the evolving demands of the business environment. Fourth, EA increases organization flexibility to manage changes during BDA implementation (Gong et al. 2020).

There are three roles identified in *technology-related support*. First, EA helps to manage BDA complexities, e.g., by using modular structures and building blocks to reduce BDA complexity and derive stakeholder viewpoints (Burmeister et al. 2018). Second, EA supports the storage, integration and synchronization of data sources, e.g., by defining data architecture, data catalogue, metadata and technology standards (Kehrer et al. 2016). EA promotes the use of data management tools and techniques (i.e., master data management, data asset management) to address issues with data heterogeneity, inconsistency and uncertainty. Third, EA supports in delivering BDA requirements, meta-models to document elements of BDA, and methods that provide common language and framework (Kearny et al. 2016; Kehrer et al. 2016). EA offers a methodological approach to manage BDA endeavours using EA framework, e.g., TOGAF, to generate a single coherent view, integrate heterogeneous data, create an architecture vision, maintain EA repository for BDA components, and manage stakeholders' views related to BDA impacts and their interdependencies.

In the third category, EA facilitates *collaboration-related support* by enhancing communication among stakeholders, facilitating shared and re-used, and identifying required capability. First, EA can foster collaboration of multidisciplinary stakeholders to align business needs and technological capabilities, that lead toward realizing ideal BDA's target landscape (Kehrer et al. 2016). Second, EA assists in increasing shared and re-used by enacting a high-quality solution architecture practice and by implementing clear standards and guidelines (Shanks et al. 2018). Third, EA identifies a range of dynamic capabilities required for BDA implementation. These dynamic capabilities are essential to enhance organizational performance and business value creation (Gong and Janssen 2021).

EA enhances *government-related support* through four specific roles. First, since EA evolves continuously during BDA life cycle, EA can be used to evaluate BDA impacts within organization (Burmeister et al. 2018; Vanauer et al. 2015). Second, EA can deliver and enforce principles and guidelines for BDA development (Gong and Janssen 2021). Third, EA helps ensure data privacy and security, such as by documenting privacy and security aspects in EA models to support risk management during BDA transformations. Finally, EA helps in documenting current state, target state and BDA related influences (Burmeister et al. 2018).

Previous literature shows that EA roles vary across different stages of BDA implementation and evolve over time to support organizational transformation A lack of clarity of how EA roles could be played out during BDA implementation would impede the strategic utilization of resources (Braganza et al. 2017). Our in-depth case study with a large government organization enables a holistic exploration of these roles and identification of other possible EA roles that significantly support BDA implementation. Furthermore, it enables us to investigate the mechanism of how EA enhances, integrates, and orchestrates organizational and IT resources to develop required capabilities.

3 Research Method

A qualitative single case study is employed in this study, which enables an in-depth investigation in a natural setting and creates a comprehensive representation of the phenomenon of interest (Miles et al. 2014). This approach emphasizes studying the phenomenon within its context and acknowledges the lack of control over actual behavioural events by the researcher (Yin 2017). Given the complexity of BDA implementation within the organization and the need to capture multiple stakeholder viewpoints, this method is particularly relevant as it studies the phenomenon in its real setting and incorporates insights from various sources. Further, a single case study can provide a comprehensive description of a story by incorporating quotes and supporting evidence through key informants. It links the story with theory to show the connection between empirical evidence and supporting theory (Eisenhardt and Graebner 2007). Dynamic capabilities theory is suitable to address the objectives of the study as it enables firms to create, integrate and reconfigure resources in a rapidly changing environment (Teece et al. 1997). Guided by this theory, we incorporate EA in the process of sensing opportunities and threats, mobilizing various EA resources and transforming them into strategic (BDA) capabilities aligned with strategic goals and business needs (van de Wetering et al. 2020).

The study utilized primary and secondary data sources to gather information on EA roles and BDA initiatives. Primary data was collected through semi-structured interviews with key actors involved

within BDA pipelines, including IT specialists, data and analytics experts, and business process domain experts. The semi-structured interviews allow participants the freedom to express and illustrate concepts in response to the questions. The interviews were conducted online with 42 participants, and each interview lasted approximately an hour. The participants represented various roles such as senior managers, business and IT managers, solution architects, data architects, data analysts, data scientists, data engineers, and consultants. The snowball approach was used to identify additional participants based on their potential as informants. The interview questions were developed iteratively, allowing for customization based on insights from previous interviews (Klein and Myers 1999). The interviews were recorded, translated, and transcribed for data analysis. To ensure the accuracy of the information gathered through interviews, the transcripts were sent to the participants for their feedback. In addition to interviews, secondary data sources such as organizational artifacts (e.g., strategies, roadmaps, analysis document) and other documents (e.g., minutes of meeting, related consultancy reports) were collected and analysed. These sources served as a means of triangulation with the interview data.

The data analysis process involved open coding, axial coding, and selective coding, following Miles et. al. (2014). Open coding was used to identify patterns and mechanisms that connected the use of EA with BDA implementation and its impact on organizational performance. Codes were developed inductively due to the novelty of the topic. Axial coding was then employed to establish links between related concepts and categories derived from the open coding phase. Finally, selective coding was applied to connect emergent themes with theoretical concepts from existing literature (see Table 1). The data analysis process involved exploring emerging themes and existing literature to consider different explanations and develop the most suitable explanations based on the data (Yin 2017). To maintain research rigor, we ensured construct validity by employing multiple sources of evidence and incorporating key informant reviews of the case study report. Validity was maintained through the establishment of connections between relevant theories and previous literature, while the development of a case study protocol contributed to research reliability (Yin 2017).

Statement	Open coding	Axial coding	Selective coding
"[…] the initial vision for the first two years was to build a good data management so that data scientists were not really required. However, in the implementation, the leaders who once shared the same vision are no longer the decision makers […] The vision for data management is lagging, and it ultimately pursues business goals, while being constrained by the limitations of data scientists." *(Data Engineer Specialist)*	1. Initial vision	Change of strategic priority	Unstable business strategy
	2. Build a good data management		
	3. Data scientist not really required		
	4. Change in leaders	Top management rotation	
	5. Lack vision for data management	Pursue short-term goal	
	6. Pursue business goals		
	7. Limited data scientist	Goal constraint	

Table 1. Sample map of open coding, axial coding, and selective coding

4 The Case Organization

An in-depth single case study was carried out in a large government organization, referred to as GovIn, in the financial sector. The selection of GovIn as the case organization was based on its reputation for having the best practices in BDA among other government institutions. The organization's IT blueprint and transformation strategy includes EA and BDA as strategic initiatives in 2021. Organizational transformation in GovIn started in 2008 with the creation of three new transformation divisions: IT, business process, and human resources. An Information Systems Architectural Design unit was established under the IT division with a specific task to improve alignment between business and IT, which is the main goal of EA. The unit oversees gathering business requirements, analysing them, and submitting the final requirements to application developers as a baseline for application development.

The second organizational transformation took place in 2019, with one of the recommendations being the creation of the data division, with functions distinct from those of the IT division. In the IT division, a new middleware division is established as a result of the adoption of new technological infrastructure,

such as Service Oriented Architecture (SOA), which requires continual infrastructure development and maintenance. The data division maintains the end-to-end data pipelines in supporting data analytics. In response to the rapidly changing demand for BDA, a new data analytics division, Compliance Risks Management (CRM) and Business Intelligence (BI), was initiated. Different stakeholder interests as inputs for developing an integrated CRM solution create complexities in the organization's decision-making process. The new data analytics formation marked the organization's transition from a decentralized analytics structure, where analytics occurred in specific business units and resources were allocated to silo-projects, to a centralized structure, where business analysts, data analysts and data scientists collaborate in a single unit. The current BDA projects are initiated based on business strategic priorities.

5 EA Roles for BDA Implementation within the Organization's Case Study

Based on the interviews conducted and triangulated with secondary data source, we found 18 roles of EA in supporting BDA implementation. Six EA roles are related to strategy related support (Role 1– 6), four roles are linked to technology (Role 8-11), three roles are related to collaboration (12-14) and five roles are matched with governance (Role 15-19). The description of each role is presented below.

5. 1 Strategy-Related Roles

Role 1 - EA guides strategic planning and facilitates development of strategic capabilities

GovIn has incorporated EA in designing strategic plans for each unit to ensure alignment across divisions and hierarchical layers. By utilizing Orbus iServer and Archimate as EA tool and EA notation, respectively. EA provides a strategic planning for organization transformation. The EA solution architect pointed out *"EA serves as a tool to explore vision and determine direction, enabling a comprehensive view of national-level planning and innovations."* EA is used to communicate the direction of BDA and establish targets and KPIs for units involved in the BDA pipeline. It ensures consistency and alignment with business objectives.

EA supports the development of strategic capabilities in GovIn through the deployment and orchestration of EA resources. EA provides the capacities to adjust, integrate, and deploy internal and external resources to address dynamic change of BDA environment. From the interviews, we identify three major orchestrations of EA resources to build dynamic capabilities in supporting BDA implementation, which are EA supports in creating the hub for development of capabilities (or Centre of Excellence), developing data-driven business models for Compliance Risks Management (CRM) application, adopting hybrid mechanisms for BDA initiatives, and integrating the Human Resources Information Systems and the Enterprises Resource Planning system. EA plays various roles in developing each strategic capability by orchestrating EA resources.

Role 2 – EA aligns Centre of Excellence' objectives with the organization's strategic goals

EA contributes to the establishment of a Centre of Excellence (CoE) hub by aligning its scope and objectives with the organization's strategic goals. The CoE enables the recruitment and deployment of talented individuals and drives the BDA strategy. It operates under the Centre for Transformation Office (CTO), which oversees digital transformation and guides EA and BDA initiatives. Even though the task of the CTO is to monitor the progress of data analytics projects across the organization and ensures compliance with EA guidelines, a data architect emphasizes that their role is: *"to act as a coach, helping to solve problems rather than burdening units with additional tasks and constant monitoring."*

Role 3 – EA supports development of data-driven business models

The development of CRM modules in GovIn follows the CRISP-DM (Cross-Industry Standard Process for Data Mining) method. CRISP-DM is a well-established and standardized data mining process that follows iterative phases from business understanding, data understanding, data preparation and modelling, evaluation to deployment. EA leverages CRISP-DM method to enhance both business and data understanding. EA supports business understanding by delivering standardized template for capturing business requirements and communicating updates or changes to stakeholders. EA enhances data understanding by exploring existing data characteristics, performing statistical analysis and validating data quality. A business transformation specialist emphasizes the importance of creative and business-oriented thinking in developing BDA predictive models.

Role 4 – EA improves organizational responsiveness and flexibility

EA can be utilized as a strategy to improve organizational responsiveness and flexibility. EA assists in searching for the required talent across the organization and providing training for specific BDA-related skills. BDA projects require managing data complexities throughout their lifecycle (streaming and ingestion, integration, interpretation, visualization) with each process demanding distinct skills and capabilities. Adopting a BDA team structure with diverse backgrounds can bridge the gap in cross-departmental collaboration and improve business and IT alignment. However, the current bureaucratic process in GovIn hinders the establishment of data analytics in each unit. As a solution, an EA architect asserted *"creating a squad team that can be assigned to a unit helps to address skill gaps in units running BDA projects."* EA supports in creating a flexible squad team within the organization that can recruit, rotate, and deploy staff. Other units running BDA projects and lacking BDA expertise can borrow staff from this squad team to support their projects. This approach increases flexibility, which allows employees to work in different roles and processes while providing the organization with the ability to reallocate staff across different business units. Establishing a Centre of Excellent to gather EA expertise enables the recruitment and deployment of skilled individuals and drives the BDA strategy.

Role 5 – EA supports the adoption of a hybrid BDA strategy

EA plays a crucial role in supporting and shaping BDA initiatives in GovIn by adopting a hybrid strategy. EA facilitates the implementation of both top-down and bottom-up BDA strategies, ensuring alignment with GovIn's overall business goals. The analytics unit has developed BDA application in the form of online dashboard and reporting system. This application is intended for use by the vertical units to harness tax potentials within their respective regions. Nevertheless, the analytics application created by the head office is considered inadequate for the specific needs of the regional units. The local units innovate as they integrated central data with region-specific data to develop their desired analytical applications. Adopting a hybrid strategy, the centralized IT organization in GovIn manages and operates most of the infrastructure and enterprise-wide applications as shared services. In addition, business units maintain control over specific applications, data, and development resources. The hybrid strategy integrates both top-down and bottom-up approaches.

Role 6 – EA supports the alignment of business and IT through development of business use cases and agile method

With the top-down strategy, EA ensures that BDA initiatives are aligned with the overall business strategy. The recruitment of domain experts and data analysts from different departments into the CoE brings business owners and data analysts closer in addressing business problems. It also promotes the sharing and reuse of infrastructure and application tools while reducing the need for multiple tool licenses. In the top-down approach, an advanced analytical unit at the headquarters gathers and analyses business requirements, develops analytics, and introduces BDA as a strategic initiative within the organization. This approach also involves implementing BDA governance principles and executing business use cases to identify the value of BDA initiatives. Development of a use case is a prerequisite before an analytics proposal can be assessed and validation of the use case by top management is necessary to proceed with a BDA project. Data analytics manager commented that *"no data analytics initiative without business use cases."*

EA also supports agile development using Scrum method to gather business requirements. A business manager in GovIn asserted that *"the processes (using Scrum) require quick feedback with our tasks to create scenarios and use cases to be given to the development team."* It ensures that the use cases scenarios evolve based on continuous feedback and refinement. EA can help in simplifying the use cases by streamlining the analysis process and prevent delays caused by data-related issues.

5. 2 Technology-Related Roles

Role 7 – EA guides the selection and evaluation of BDA technologies

With the bottom-up strategy, EA guides the selection and evaluation of BDA technologies that align with GovIn's architectural landscape. The business manager pointed out, *"[…] by granting vertical units predefined access rights to data that can be used for independent analysis. It enables them to delve into the data, create business models, and visualize the insights."* By distributing data and analytical tools to vertical units, EA can promote knowledge sharing and innovation. Each unit can explore the potential of BDA and reuse best practices, leading to increased efficiency and effectiveness across the organization. EA facilitates collaboration and data sharing across units, enabling decentralized data analytics efforts.

Role 8 – EA provides standard technologies that minimize BDA implementation complexities

EA simplifies BDA complexities by implementing standardized technology, such as utilizing loosely coupled services, where services are designed to be modular and can function independently. Compliance with EA standard helps to reduce infrastructure heterogeneity and increase application interoperability. GovIn and its corporate customers have established a host-to-host network for transferring large volumes of data.

Role 9 – EA aligns BDA technology solutions and business requirements

EA assists in aligning technology solutions with business requirements, such as selecting secure and reliable data transfer technologies like MSMQ. According to the lead IT architect *"Message Queuing technology is suitable for sending large amounts of data and offers enhanced security through encryption and decryption."* This technology has mechanisms in place to handle network interruptions and automatically resume file transfers in case of network recovery. EA assists in establishing business policies for network failure and implementing IT controls to ensure prompt system recovery in the event of an interruption. The transfer systems mechanism was outsourced to an external vendor and required to adhere to GovIn's Reference Architecture through the implementation of a Service-Oriented Architecture design concept.

Role 10 – EA enables automation, integration and interoperability and reduces costs

EA enables integration and interoperability by supporting the development of middleware technology, such as Service-Oriented Architecture (SOA) and Application Programming Interface (API). These technologies are crucial for automation, interoperability, and eliminating redundancy. SOA enables the integration of loosely coupled services, ensuring that system failures do not impact other systems. It serves as a solution for unstandardized technology across heterogeneous platforms. Further, the use of API provides benefits to both GovIn and corporate clients. EA also allows automation through instant synchronization of client services with GovIn's server, eliminating the need for customers to upgrade their applications for updates. The lead IT architect pointed out "*when the rules on any channel change (desktop, web, and host-to-host), the change can be facilitated directly through the back office.*" Having a single back-office across multiple platforms reduces maintenance costs for GovIn and enhances business process standardization, which lead to a more efficient operating model.

5. 3 Collaboration-Related Roles

Role 11 - EA identifies required capabilities for BDA adoption

EA plays a vital role in identifying the required competencies for specific functions within GovIn and aligning them with the organization's strategy and goals. A significant capability being developed in GovIn is the ability to match organizational tasks with employee skills. The organization's business strategy requires selecting the right individuals for specific tasks, which leads toward the integration of the Human Resources Information System (HRIS) and the Enterprises Resource Planning (ERP) System. By documenting each case and analysing the statistics and results of prior assignments, suitable individuals with the necessary job skills can be efficiently assigned to cases. The organization envisions a diverse staff with a broad range of expertise, ensuring that the right individuals with qualified capacities handle specific assignments.

"In principle, the system must be able to record complete documentaries of employees' portfolios, their interaction during tasks fulfillment, to acknowledge how the organization make use of its resources to face future challenges" (Business Manager)

Through a competency-based approach, individual capabilities are aligned with the organization's core competencies. This involves identifying key roles critical to the success of BDA initiatives and assessing the competencies needed to fulfill the roles within BDA pipelines. EA helps identify any gaps between the required competencies and the existing skillset of current employees. By recognizing these gaps, GovIn can develop strategies to narrow them, such as providing training (both hard skills and soft skills), workshops, and fostering collaboration between roles.

Role 12 - EA fosters team collaboration and encourages analytical culture and risk-taking

EA can enhance communication across BDA teams, such as data scientists and business users, to understand the business problems. GovIn is partnering with internal and external parties to co-create BDA value through innovative analytical products and services. Collaboration is a crucial element of the analytics culture. EA facilitates collaboration between Subject Matter Experts (SMEs), such as domain experts and auditors, and the analytics team in developing use cases and modelling analytical products.

Even if BDA outcomes are superior to SMEs' knowledge in addressing business problems, the head of data analytics emphasized that *"a culture of respect should exist."* The SMEs can act as liaisons, leveraging their expertise and the trust they have earned from the executives, to gain executive buy-in. EA helps develop a culture that encourage analytical experimentation with new ideas and methods and nurture a mindset that embraces risk-taking and the acceptance of failure. This process begins with small, incremental changes and eventually leads to novel innovation.

Role 13 – EA fosters the use of EA repository to promote transparency, shared and reuse

Furthermore, utilizing an EA repository enhances team communication, promotes reuse and sharing, and fosters transparency. The repository is used as a platform to support sharing ideas. It enables architects and data scientists to exchange information that others can view and respond to, which facilitates collaboration. In addition to a digital library for storing work products, the repository is a knowledge management resource. A senior data scientist commented "*a lot of knowledge is owned personally. We can store all this knowledge in a repository for share and reuse, reducing our reliance on people*". Further, the repository can be integrated with project management tools like Jira and supports source code management and collaboration on software development projects like Bitbucket. This integration and interoperability streamline tasks and ensure immediate visibility of outputs within the repository.

5. 4 Governance-Related Roles

Role 14 – EA supports BDA Governance Mechanisms

EA plays a significant role in supporting BDA governance mechanisms by harmonizing the organizational structure with the tasks and responsibilities of various stakeholders throughout the BDA processes. Moreover, EA assists in shaping BDA governance policies that balance data protection with the utilization of data assets. For instance, providing raw data to business units across GovIn may pose security risks, but it also encourages experimentation, exploration, and the discovery of valuable insights. EA facilitates the assignment of authorization levels for data access, considering roles and responsibilities, hierarchies, escalation procedures, decision-making processes, and communication channels to enhance effective BDA governance. The structure of BDA governance is outlined below.

The BDA governance structure in GovIn consists of three layers: strategy, management, and operations (Figure 1). A high-level steering committee translates the business vision into strategic goals and shares them with stakeholders. The committee oversees BDA governance, reviews policies and strategic plans, and resolves data and IT-related issues. The Chief Data Officer (CDO) leads the Data Governance (DG) Council, ensuring strategic goals are met and reporting issues to executive sponsors. They also evaluate business cases and BDA value. The BDA Governance Working Group operates at the operational level, ensuring daily plans are executed, KPIs are met, and issues are resolved or escalated to management governance when necessary.
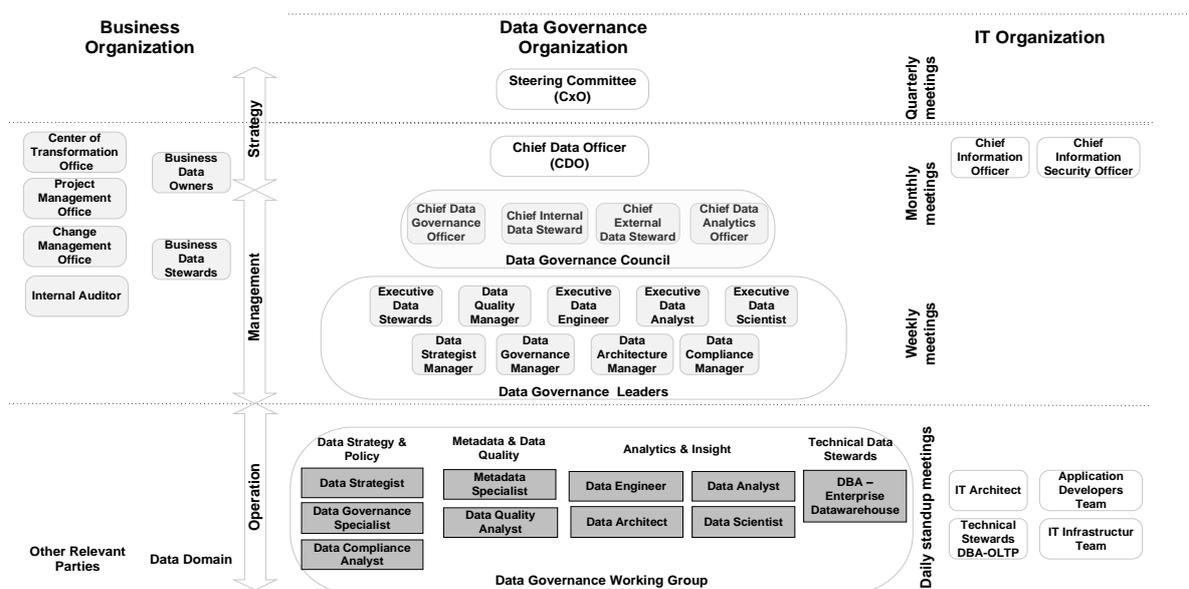

Figure 1. BDA Governance Structure

Role 15 – EA identifies key stakeholders, and balancing their perspectives and concerns

EA helps identify and understand key stakeholders, addressing their perspectives and concerns. This helps limit decision-making parties and reduce the complexity of BDA governance. Engaging stakeholders early on, such as addressing knowledge gaps and recruiting skilled personnel, allows their concerns to be addressed promptly and gain executive attention. For instance, EA stakeholders with competing interests are represented in the governance body, including potential conflicts between business owners and the Compliance Risks Management (CRM) team. Business owners prioritize local optimization and short-term BDA value, while CRM focuses on integrating all business requirements into a long-term plan through a risk engine. A well-structured governance framework can ensure a balance of perspectives from different stakeholders. An EA solution architect emphasized the role of EA as an orchestrator, offering recommendations for professional recruitment and raising awareness among top leadership. Aligning BDA governance with the EA organizational structure ensures standardized and effective procedures for BDA actors.

Role 16 – EA helps in setting coordinating among BDA actors

EA also helps establish coordination between BDA governance actors. EA promotes clear communication channels and facilitates stakeholder engagement through regular meetings, training, workshops to ensure the governance mechanisms align with their needs and expectations. This includes scheduling meetings, setting meeting agendas, ensuring key actors' attendance, documenting minutes of meeting and executable actions. The frequency of these meetings varies based on hierarchical levels. The DG steering committee conducts quarterly meetings to address strategic matters and resolve escalated issues from the managerial level. The DG Council, representing top management, holds monthly meetings, while the DG Leaders, representing mid-level managers, meet on a weekly basis. Operational working groups run stand up daily meetings to address routine data-related issues.

Role 17 – EA enhances data privacy protection and security

EA assists in enhancing data privacy protection and security by identifying roles and responsibilities, establishing role hierarchies, and implementing role-based access control (RBAC) to mitigate unauthorized access risks. RBAC controls application access for user groups, with user credentials maintained in an active directory linked to an HRIS database containing employee profiles, access roles, and assignments. According to a data security specialist *"[...] by configuring user roles in the active directory, we can grant access to data, applications, and hardware, which contingent upon registration to the joint domain."* Since joint domain involves the integration of systems, processes, and data across different domains, EA can help by guiding the integration and interoperability standards.

Role 18 – EA guides IT procurement processes

EA can assist in guiding IT procurement processes by ensuring the availability of documentation, such as the existing (as-is) and future (to-be) architectural landscapes and by adhering procurement standards, such as using Gartner magic quadrant criteria. The EA solution architect stated that *"As all IT procurement is now centralized within our unit, we mandate that all echelon-1 units proposing new IT infrastructure must submit project proposals, including documentation of their current and future architectural layers, and the roadmaps, within the unit. It will increase their compliance toward EA and ensure that IT development adheres to EA guidelines."*

6 Discussion

This paper investigates the contribution of EA practices to BDA implementation. Throughout BDA implementation process, EA can be employed in various ways, each demanding a specific set of capabilities across strategy, technology, collaboration, and governance. Further, our research identifies a total of 18 distinct roles of EA. While prior studies indicated that EA played a more dominant role in technology and collaboration support compared to strategy and governance, our findings reveal a shifting landscape. EA's role in strategy has become increasingly significant, comprising six roles, in contrast to its roles in technology (4), collaboration (3), and governance (5). Our findings complement EA roles that have been identified in previous studies within a broader context rather than specific to the BDA context, such as facilitating the use of EA repository, fostering team collaboration (Kurnia et al. 2020; Niemi and Pekkola 2017), and guiding the IT procurement process (Lagerström et al. 2011).

In addition to the 14 EA roles described in previous literature, which are also identified in this study, our findings introduce novel roles that are specifically related to strategy (Role 5) and governance (Role 18). In strategy-related support, EA plays a critical role in the adoption of hybrid BDA strategies that span all stages of strategic planning processes, including strategy formulation, strategy implementation,

and strategy evaluation (Blomqvist et al. 2015; Simon et al. 2014). Strategy formulation encompasses strategic analysis and strategic choices, whereas strategy implementation involves resource allocation, aligning structure with the strategy, and linking performance to the strategy (Blomqvist et al. 2015). Strategy formulation and implementation align with the top-down approach, while strategy evaluation, which includes strategy review, performance evaluation, and corrective action, is associated with the bottom-up approach.

Utilizing the top-down strategy, strategy formulation in GovIn leverages its business understanding of BDA issues by analysing internal and external factors and sets the strategic decisions based on the availability and quality of the data. As EA is subject to constant change driven by BDA, the concerns of stakeholders affected by EA also evolve (Burmeister et al. 2018). The information created by EA can be harnessed to translate the selected strategy into a data-driven business model in a more structured manner (Blomqvist et al. 2015). Furthermore, the data-driven business model requires EA support for use case design and implementation, with EA assisting in use case sequencing and prioritization (Rashed and Drews 2020).

Similar to the strategy implementation described earlier, GovIn deploys specific EA resources to develop the required dynamic capabilities. Dynamic capabilities provide firms with access to previously unavailable EA resources (van de Wetering et al. 2020) and can be leveraged with structured adoptions of BDA (Mikalef et al. 2021). For instance, the integration of HRIS and ERP system enabling GovIn to search for staffs with the right skills based on their experiences and prior achievements. In addition, dynamic capabilities are essential for creating business model. Creating innovative business models is a crucial foundation for a firm's ability to seize opportunities (Schoemaker et al. 2018). Furthermore, EA ensures that roles within the enacted organizational structure collaborate synergistically to achieve strategic goals and assists in establishing KPIs based on the goals.

Concerning strategy evaluation, the top-down approach acknowledges the value of feedback and innovation from the bottom-up. The bottom-up approach allows vertical units to review the existing strategy and propose alternative methods or adaptations to meet local business specific needs. This approach promotes organizational flexibility and responsiveness, with EA playing a key role in aligning various organizational elements such as business processes, people, skills, data, and technology (Van de Wetering et al. 2020). In summary, EA support in adopting hybrid BDA strategies requires an integration of both top-down and bottom-up approaches that covers all phases within the strategic planning processes.

In governance-related support, the introduction of new technology often triggers bottom-up changes in IT that support business processes. GovIn needs guidelines to integrate the existing middleware technology (SOA) for processing external host-to-host data with the new Enterprise Datawarehouse (DWH). EA facilitates this integration by incorporating SOA within the DWH procurement guidelines. It ensures new business processes adapt with SOA principles and aligns the vendor's technical solution with the current SOA technology. Distributed SOA solutions enable dynamic integration of BDA information and systems with the business (Pathak et al. 2021).

While the results underscore the critical importance of EA for strategic planning and governance, the effectiveness of these EA roles can be influenced by various internal and external factors. For instance, EA roles in guiding IT procurement processes require internal buy-in from top management. This support is crucial for ensuring effective governance throughout the procurement process. The lack of executive support may result in a lack of attention on the initiatives and lead to inefficient resource allocation, a lack of accountability, and non-compliance with architectural guidelines.

Furthermore, external pressures in the government sector, such as the need to generate more taxes and customs revenue, often lead to deviations from the original plan. In the case of GovIn, the initial focus on improving data quality shifted towards generating multiple business use cases to leverage BDA insights. This shift resulted in delays in deploying BDA initiatives due to resource imbalances and skill gaps among data engineers. Hence, the role of EA in strategy can be compromised, primarily due to frequent changes in the business strategy (Kotusev et al. 2020). The changes in strategy are driven by issues related to coordination and leadership (i.e., top management rotation), which results in a failure to effectively communicate the organization's global vision. EA can help address this challenge by facilitating communication and sharing a focused vision of the business strategy (Hafsi and Assar 2019).

These challenges also underscore the differing perspectives between managers and data analysts. Managers often prioritize quick returns on investments, while data analysts prioritize the accuracy of BDA outcomes (Yamada and Peran 2017). To address these issues, EA can play a critical role by establishing BDA governance arrangements and ensuring alignment between organization visions and

target plans. Additionally, fostering closer communication between business and IT domains through regular meetings can help identify issues earlier and escalate them to higher management levels.

These findings align with the broader focus of recent EA studies, which have shifted from a narrow IT context to a more managerial and business-oriented perspective (Shanks et al., 2018). Other research supports these findings. Gong et. al.'s study showed that digital transformation in the public sector relates to a shift in flexibility from technology-enabled to policy-enabled, indicating a move towards flexible organizational structures and a user-centric culture (Gong et al., 2020).

Achieving successful organizational transformation through BDA requires different sets of EA flexibilities (Gong et al., 2020). The establishment of the Center of Excellent promotes worker and organizational flexibility by identifying and deploying skilled personnel across units (Dremel et al., 2020; Vanauer et al., 2015). Worker flexibility required staff to have sufficient capabilities to support various BDA positions, and organizational flexibility allows staff to be placed in multiple business units while being compliant with regulations (Gong et al., 2020).

Additionally, employing a top-down approach by involving top management can enhance strategic flexibility, as they can provide strategic direction and resources into the areas where BDA can create value and derive meaningful business questions (Vidgen et al. 2017). On the other hand, the bottom-up strategy promotes flexibility of experimenting and learning by doing, which underlines EA supports in creating innovative BDA applications (Gong & Janssen, 2021). The formation of a BDA governance structure can also improve coordination flexibility of talent management, for instance, by mapping BDA roadmap with tasks, skills required, and knowledge gaps need to be addressed for early awareness of the C-level. The governance mechanism helps to break the organization silos and integrate knowledge and expertise from different units (Mikalef and Krogstie 2019; Tallon 2013).

This study contributes to academic literature by discovering synergistic mechanisms of EA resources to enhance BDA capabilities and drive organizational transformation to increase the likelihood of BDA implementation success. It also outlines how EA guides BDA structural mechanisms and identifies BDA actors' roles and responsibilities, which provides insights into governing BDA efforts. This study also contributes to knowledge by empirically revealing the role of EA in supporting strategy review. In contrast to the prior empirical study by Blomqvist et al. (2015), indicating a limited role of EA in strategy evaluation, EA not only supports strategy formulation and implementation using top-down approach but also plays a significant role in strategy evaluation through a bottom-up approach. Furthermore, this study offers a rich case study to explore the integration of BDA into EA organizational landscape. It is a revelatory case, as it is not common for a researcher to gain access to a case organization for an extended period of time, develop relationships with key stakeholders to elicit the necessary details, and observe actors' interactions within BDA pipelines.

From a practical standpoint, this study helps managers understand the evolving roles of EA during BDA implementation and how they can be adjusted to align with BDA characteristics. Employing hybrid BDA strategies, by combining top-down and bottom-up approaches, offers flexibility for business managers to adapt analytical models to meet specific requirements. This approach also allows them to create their own KPIs and metrics. In addition, IT managers can leverage this strategy to promote data and knowledge sharing across departments. This, in turn, facilitates the development of suitable solutions and innovative concepts.

7 Conclusion

This paper presents EA roles for managing BDA integration and highlights 18 specific roles in which EA can enhance BDA implementation. The execution of these roles directly contributes to the success of BDA implementation, and a lack of clarity in these roles hinders the strategic utilization of EA resources. Further, deployment of EA resources into strategic capabilities is explored through dynamic capabilities lens. The absence of holistic governance mechanism can hinder the orchestration of EA resources, leading to failures in BDA implementation.

This study has limitations as it focuses on a single case study within a large public sector organization. Thus, the findings may have a specific bureaucratic context and may not directly apply to private sector organizations. However, by linking the specific details gathered from the field study to theoretical concepts, the theories utilized in this study can be applied more broadly to draw generalizations. Future research could investigate the role of EA in integrating BDA, specifically in relation to strategy, which is currently seen as having limitations. Embracing innovative working methods like Agile and Scrum, which can enhance collaboration flexibility among BDA team members, could be an effective way to bridge this gap.

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8 References

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