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Scaling Up the Agility of Data Management by Scaled Agile Data Management Framework (SADMF)

Milad Padidarfard[1], Atefeh Sharif[2,*], Mohammad Hasanzadeh[3], Mostafa Amini[4], Amin Nezarat[5]

1. Ph.D. Candidate of Knowledge and Information Science, Tarbiat Modares University, Tehran, Iran. m_padidarfard@modares.ac.ir, 0009-0004-3369-0711

2. Assistant Prof., Knowledge and Information Science, Tarbiat Modares University, Tehran, Iran. (Corresponding Author), atefeh.sharif@modares.ac.ir, 0000-0003-4761-6761
3. Full-Prof., Knowledge and Information Science, Tarbiat Modares University, Tehran, Iran. hasanzadeh@modares.ac.ir, 0000-0002-6175-0855
4. Post-doc., Knowledge and Information Science, Tarbiat Modares University, Tehran, Iran. 0000-0002-6673-3851
5. Ph.D. Researcher, ICT Research Institute, Tehran, Iran. 0000- 0002-2445-7254

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ABSTRACT

The research aims to design a scalable agile data management framework leading to the success in data-oriented decision-making and ultimately smartness and data intelligence using agile manifesto and scalability. The main paradigm is data-driven, lean thinking and agile manifesto. As an applied and developmental research, argument, analogy and discovery are used to draw conclusions. In this research Design Science Research Methodology (DSRM) is applied. Thus, firstly, the problem was defined clearly via literature review. Secondly, objectives of solution were specified specifically. Thirdly, the artifact (SADMF) was designed and developed via iterations through SCRUM. Fourthly, validity and reliability were evaluated by SMEs and finally the results were formalized and academics and practitioners were invited to consider reflective thinking. There are various reference models for the concepts of agile, data management, Information System and Software Engineering, but few of them practically embedded agile practices in a scalable management system, despite the remarkable importance of agility in the optimal data management of social-physical-cyber systems today. So, there is an essential need to design a comprehensive model. Scaled agile data management requires leanness and agility. This framework has three levels including portfolio, program and data lab and four main elements including people and organization, agile process and practice, technology and knowledge areas. Finally, considering the selected references, a Scalable Agile Data Management Framework (SADMF) from combination of agile best practices along with the main elements of a data management system was designed and offered.

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1. Introduction

Today, data is known as the key asset of the organizations and societies. Data interconnection in different industries is the reason of value chain integration and eliminating the borders of different ecosystems. Economic players are continuously trying to manage data optimally in order to provide their customers and stakeholders with sustainable added value. Now we are faced with social-physical-cyber systems that are the basis of data creation and data flow, the type of these systems is transformational and data-oriented digital transformation is achieved by data flow management in these systems (Garshivaz, 2022).

Smart and agile data on one hand, provides the interaction of different ecosystem platforms affected by disruptive technologies and on the other hand, they fuel business intelligence and analysis capability engine so that they can include continuous service innovation with maximum data interactivity.

Agility is the key to decision-making and intelligence, and businesses have learned through their initiatives all over digital transformation, that for being agile, simply making processes, technologies and tools agile does not suffice, as in order to win a relay race, the entire elements of organization must be capable and agile. Therefore, it is important and essential that the concept of agility to be considered integrally and comprehensively at an appropriate scale and the necessary mechanism for agile data management and agile data should also be provided as well.

On the other hand, the necessity of agility in today's volatile, uncertain, complex and ambiguous world has led to the emergence of agile thinking and fundamental changes in classical management systems and methods (PMI & Agile Alliance, 2017). By the emergence of the Agile Manifesto, we are witnessing the emergence of new concepts such as Agile Information Technology, Agile Data, Agile Analysis, Agile Business Intelligence, Agile Data Governance, AIOps, MLOps, DataOps and other such cases, to the extent that agility is considered as a key trait for success in today's management world. As due to digital maturity progress organizations are moving towards intelligence, they have chosen data-orientation and data management as a strategic competency to achieve intelligence. The critical success factor for achieving this competency is having an agile data management system.

Scaling up the agility of data management is important for today's organizations due to:

- The importance of scalability in today's management solutions;
- The need for gradual implementation of initiatives;
- Saving time and financial costs;
- Data as a fuel for digital transformation;
- Timely and fast access to relevant information;
- High success rate of agile approaches in management systems and initiatives;
- The increasing criticality of data security issues;

The problem here is the lack of a scalable framework for managing this data and it is because of the fact that, the issue of data management is an interdisciplinary concept, which results in a wicked problem. Many reference models have been presented by academics and practitioners, but none of them have paid the necessary attention to the capability of agility and scalability.

Organizations require a customized framework including the required data management capabilities to eventually guarantee the intelligence and agility of data at different scales. Therefore, this article is trying to deliver a new scalable agile framework for managing data in today social-physical-cyber systems.

2. Literature Review

Studies on data management and agile management prove that the welfare industry has the most tendency towards agility in data management, and undoubtedly this is due to the important role of agile data in making critical and intelligent decisions for human welfare. Although some data management studies have noticed the importance of agility to some extent, but they have not provided a solution for scalability. Regarding the concept of agility, it is obvious that the presented agile methods are mostly designed at team and

project level, and less attention is paid to the issue of increasing architectural scale and customizing the presented method for a specific management discipline. In order to avoid the complexity and better organization of the research background, the studies are divided into two groups including agile management and data management.

2.1. Background Related to Data Management

The data management revolution in organizations includes three phases (Legner, Pentek, & Otto, 2020):

1. The first phase - from 1980 to 1990 - data monitoring;
2. The second phase - from 1990 to 2010 - quality-oriented data management;
3. The third phase from 2010 up to now – expansion to strategic data management.

Many companies use reference models which assist them in creating strategic, organizational and systems capabilities required for data management. As a matter of fact, considerable knowledge is accumulated in the form of data management frameworks and reference models. According to a systematic review of professional and academic sources, more than 10 reference models of data management are recognized. The development of reference models is often due to the work of experts in industry-specific consortia or data management associations and the combination of their practical experiences. The popularity of these frameworks which form data management practices not only underpins the practical relevance and challenges of data management, but also represents a significant body of design knowledge which is developed through the efforts of researchers and practitioners.

They introduced common reference models in their research, and the DAMA framework is introduced in this research as one of the appropriate data management frameworks (Legner, Pentek, & Otto, 2020). In this research, considering the comprehensiveness of knowledge areas of data management in the framework of DAMA, this framework is considered as the design criterion.

The main rationale for defining the boundaries and management framework in any system is its life cycle, for example Software Development Life Cycle (SDLC) is used to produce and develop software or for project management, the project life cycle (PLC) is used to define their management framework (PMI & Agile Alliance, 2017). In the DMBOK 2.0 guide, the data life cycle is also recommended for the data management framework (DAMA, 2009). But today, this linear and predictive approach to management is challenged by the Agile Manifesto. According to agile methods, the recommended approach for the complex and unpredictable contexts of socio-physical and cyber systems, is using iterative and incremental methods for lean management of the value chain (PMI & Agile Alliance, 2017). According to the SAFe (Scaled Agile Framework) framework, value streams are defined as a set of steps that an organization takes to create solutions that bring a continuous flow of value to the customer. This framework divides value streams into two groups: Operational value stream and Development value stream (An ambidexterity approach towards business target operating model (TOM)) (SAFe, 2018).

Management systems have recently mentioned the importance of agility in their new editions. For example, one of the useful management systems today is information technology service management system ITIL 4.0. This system introduces its management core as Service Value System (SVS), which means the organizational value chains. This system has introduced its main components as organizations and people, information and technology, partners and suppliers, and processes and value streams (ITIL Foundation 4th edition, 2019).

ITIL 4.0's systematic and comprehensive look towards different types of organizational value streams encourages us to recognize organizational data types. From Data science point of view in the digital age, we can study and categorize big data from two dimensions.

- The first dimension is whether the data source is within the boundaries of the business or outside of it.
- The second dimension is that in which layer of the business the data will be produced and used.

Once these macro dimensions meet, a four-cell matrix (Figure 1) will be created as follows:

Figure 1. *Data Science in the Digital Age (ITIL Foundation 4th edition, 2019)*

1. External data – Internal Data
2. Strategic – Operational
3. Strategic Internal Data - Strategic External Data
4. Operational Internal Data - Operational External Data

Convey Law is a principle that claims the design of a software system reflects the communication structure of the organization that creates it. Thus, by applying this law in data-oriented organizations, we can conclude that the structure of data products and data-oriented value streams reflects the structure of the organization which creates it.

Following the literature review & influenced by the main elements of the data supply chain, including these three groups: data production and supply, data integration and storage, and finally data demand and consumption, we categorize the background of the related researches and theories according to the type of their focus in these three groups (It's underlined that researches focusing on the entire supply chain are categorized in the first group).

2.1.1. Researches Focusing on Data Production and Data Supply

In the welfare industry the existing models for data governance and data management do not seem to provide the agility that the business needs for data governance and data management. According to their research, seven key capabilities necessary to achieve agility are Competency, Flexibility, Leanness, Reusability, Scalability, Speed and Responsiveness. This research is solely focused on data governance, and although it points out the importance of agility and scalability, it does not discuss how it works. (Lillie, Theresa, & Sunet, 2019).

Reconsidering the triple constraints related to project management knowledge, a shifting focus from scope management to time and resource management is noticeable. In a research with the title of "Agile project management approach and its use in Big Data Management" that was conducted in order to answer the question: "What is the right approach for managing big data projects?!" if we compare based on the triple constraints of the project, based on Figure 2, it is evident that the agile approach is preferable for managing big data projects. This happens due to constantly changing needs following up new arising questions. According to their recommendation, on implementing a big data project, we should take small steps, accept small failures proceed us, and continue this iterative approach. Although this research studies the importance of agility, it only focuses on big data management and is not scalable (Frankova, Drahosava, & Balco, 2016).

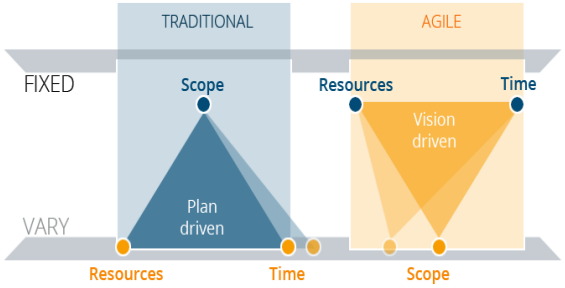

Figure 2. *Focus Shift in Project Management Triple Constraints (PMI & Agile Alliance, 2017)*

McKinsey & Company, 2016 brought up a new perspective on data management; the importance of considering data as a product. McKinsey & Company in "Agile Use to Accelerate Data Transformation" article mentioned that agile data is similar to agile software development, that is, it extremely relies on joint collaboration between business and information technology. Multitasking teams work in "Data Labs" focusing on providing reliable insights from data sources. Instead of waiting for "Perfect" solutions to come up, these labs develop products and systems as minimum viable product (MVP)

for data transfer. McKinsey recommends companies to first use pilot projects to acquire or purchase agile data. They need to qualify working teams in data labs to make some decisions individually. They need to make the necessary modernizations in the technological infrastructure and establish new forms of measurement and communication to ensure that data provision and delivery projects are taking the right path. This research covers agility in data management at team level but it does not have a scalable view (McKinsey & Company, 2016).

Product-oriented view towards data management appears in other studies as well. For example in a research targeting graduate education information system improvement in Tanzania, used Extreme Programming (XP) as one of the agile practices and design science research method to develop a scheduling software (Anna, Lazaro, Solomon, & Matti, 2023). This system is easily integrated into the existing academic information system of the Faculty of Business Education for better and more agile decision-making and has significantly raised the stakeholders' satisfaction level. In a research titled "Agile framework as information management system delivery key", some critical methods for teams to succeed in information management systems production projects were presented. In order to achieve that, the reserchers studied project management competencies, agile practices, agile scaling frameworks and provision of project-oriented services from people, communication, infrastructure and technology aspects. These researches somehow considered agility in data management too, but they got inefficient scalability (Haidabrus, Grabis, Psarov, & Druzhinin, 2023).

A case study also conducted to prove the success of the data-driven product approach. In this research titled "Integration of design thinking and agile methods in the production and development of analysis tools in Aginic Company", the researchers studied how the use of agile practices and design thinking in analysis helped the sustainability of Aginic Company (Edgar, Ida, Emma, Brett, & Sadiq, 2023). This research finds the key factors that lead to the successful integration of agile values and design approaches and gives the reader the opportunity to gain a deep understanding of how such an integration can facilitate the production and development of innovative data analytics products. This case study also simply deals with the agility practice in data production at team level and analytical products and overlooks scalability and other agile practices.

To clarify the data-oriented product view, let's take a look at Amazon. This company went towards product orientation in the early 2000s, as the rapid growth of their business made them grow from a small book selling company to a multi-national and multi-dimensional organization. Amazon realized the complexity and interdependencies of the business increases as they grow, and this going to slow down their pace of innovation.

They found out it's crucial to reinvent performance to foster agility, eliminate dependencies, and allow innovation across the organization. So, they needed to imagine their world as a product and then divide it to modular components or features (rather than integrated platforms). This reorganized teams and separated them from integrated departments, so cross-functional, independent and specific product-focused teams were created called 2 Pizza Teams. The idea is that a team should be small enough to be fed with just two pizzas.

Amazon Web Services (AWS) is a subsidiary of Amazon that provides individuals, companies and governments with cloud computing platforms and on-demand Application Programming Interface (API) in a pay-as-you-go business model. This company, as one of the specialized authorities of data management, has recently published "Modern Data Community" article and suggests the structure of 2 Pizza Teams for organizing teams at data management projects level (The Modern Data Community, 2023). Figure 3 shows an example of a 2 Pizza Team. This research also aimed agile data production management at team level, but it is limited to it.

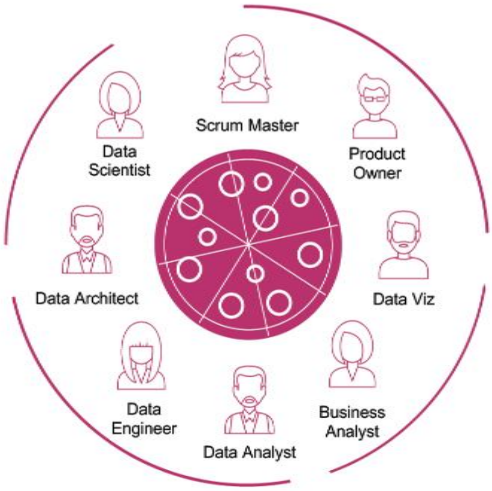

Figure 3. *An Example of a 2 Pizza Data Team at Amazon (AWS) (The Modern Data Community, 2023)*

2.1.2. Researches Focusing on Data Production, Integration and Storage

Next to considering the importance of agility in data management, the welfare industry also emphasizes on the need to re-architect its data warehouse infrastructure. For example, in an applied research in the welfare industry titled "Data management framework with a data warehouse approach", the researchers concluded that information technology contribution plays a dynamic role in supporting the quality of the care provided to the community in welfare care systems (Khalid, Surr, & Neagu, 2010). In this paper, an overview of the Dementia Care Mapping (DCM) system is presented and a framework for DCM data management based on a data warehousing approach is suggested, including collection, storage, sharing, and analysis of data in an organized and consistent manner. In this research, the concept of agility is only mentioned as a necessity and agility does not play a prominent role in the designed method.

In another research, along with "Agile data management in the NAV organization" case study (Norwegian Labor & welfare Organization) regarding data management in today's world economy discussed that to meet the need for analytical data in the development of digital services, many organizations use data warehouses and data lake architecture lately. These architectures are traditionally associated with centralized organizational models, where a single team or department is responsible for collecting, transforming and accessing analytical data. However, such centralized models assume stability and are incompatible with agile software development where applications and databases are constantly updated. To achieve more agile forms of data management, some organizations began to experiment distributed data management models such as "Data Meshes". However, no previous study has investigated this topic. Findings of this case study are reported in this article, an organization that initiated a transition from centralized to distributed data management, and expresses the benefits and challenges of a distributed approach. This research focuses more on the technological aspect of data storage and does not consider agile production and scalability (Vestues, Hanssen, Mikalsen, Buan, & Conboy, 2022).

2.1.3. Researches Focusing on Data Demand and Consumption

In one field and library research titled "Data Management System requirements in the field of welfare" researchers have come to the conclusion that welfare data management systems have undergone a disruptive transformation over the years from paper to computer, web, cloud, internet of things, big data analysis and finally to blockchain (Ismail, Materwala, Karduck, & Adem, 2019). Now a real-time welfare data management system is needed that allows physicians, patients, and external users to input their medical and lifestyle data into the system. The integration of big data analysis helps better disease prognosis, diagnosis or prediction. The prediction results help to develop an effective prevention program. This research is only about the requirements and knowledge domains of a data management system in the welfare and medical industry.

Many discussions are brought up regarding the use of analytics in fast and agile environments such as, using analytics in a democratic way and using it to enable dynamic emerging capabilities. In specialized literature, the concept of "Domain Oriented" suggested as a new tool for analytical data management. Data should be built and managed around "domains" and four principles that enable organizations to use

analytical data at scale. These four principles are (Dehghani, 2022):

1.Decentralized Domain-Oriented Data Ownership and Architecture

Data is owned and managed based on its business or subject domain, i.e., it is first the responsibility of domain teams with deeper insight into their domain.

2. Data as a product

Much like how development teams consider the software they produce as a product (or usually as a service) and have a special responsibility towards end users, data is also considered as a product. A data product should have a proper level of quality and availability, where the data owner understands the needs of data product consumer. In practical terms, a data product includes code (the Data Pipelines to access the data), data and metadata (the actual data and metadata needed to understand and use the data), and infrastructure (to run the code and store the data).

3. Self-Serve Data Platform

In similar ways, teams may use a common programming platform to deliver their software products to consumers, a platform is needed to deliver their data products to consumers, such as other teams or data analysts. This platform provides tools and infrastructure for simple provision of data as a common asset in the organization. It can be an infrastructure and a tool for creating, maintaining, publishing and sharing data products.

4.Federated Computational Governance

Following the distribution of data and responsibility for data, the need for a federal approach to data network governance and improvement is shared, including common principles and a data platform. Governance is a shared responsibility between data product owners, their consumers, and data platform product owners (Bialek, Tree, & Weisul, 2022). This research mainly focuses on the technological aspect of data storage and does not consider scalability.

2.2. Background Related to Agile Management

In this section, considering the abundance and variety of agile practices appeared in the agile literature and the lack of need for a detailed and separate review of each of these practices, the focus is mainly on comparing these practices and introducing common agile practices.

In a comparative research titled "Comparative Study of Agile Practices", in order to find the right practice for agile project management, a comparative table to study the pros & cons of agile practices was presented (Merzouk, Elhadi, Ennaji, Marzak, & Sael, 2017). In Table 1, the sign (-) indicates uncertainty, the sign (X) indicates non-determination, and the sign (√) indicates the determination of the criteria mentioned in the table.

A further point to this comparison table is the scalability criterion. Although the common agile practices have already been compared in terms of the size and dimensions of the project team, but the aspect of scalability is being missed out on most of the agile practices. Agile practices which took this criterion into consideration are:

Large Scale Scrum (LeSS), Scrum@Scale (S@S), Nexus and SAFe. A little further investigation proved that the architecture suggested for agile management in the framework of SAFe has a more logical and architectural view for the scalability of projects and repetitive and gradual initiatives of the organization. S@S framework exclusively considers distinction of the technical and business aspects of value chains within the business. As a conclusion, it seems that the Kanban methodology is the best solution for managing leanness and continuous flow of operations. This research has a comparative theme and is not customized for data management.

In a research titled "Agile Practices in Practice: Adopting an Agile Theory and Process Evolution" the researchers pointed out the difficulty of choosing an agile practice in organizations and indicated that although teams and organizations go through a lot for agile adoption, yet relatively few studies are done on how to adopt and use agile practices (Julian, Brendan, James, & Craig, 2019). To assist teams who are willing to adopt agility, we should find out how others have done this and what practical value they have found. They studied teams adopting agile practices ranging from full methodology to a few practices at a time, and then started to

continuously evaluating and improving their work practices.

Table 1. *Comparative table of agile practices* (Merzouk, Elhadi, Ennaji, Marzak, & Sael, 2017)

Practice / Criteria	SCRUM	XP	DSDM	FDD	LSD	KANBAN	CRYSTAL	ASD	SAFE	Spotify
Team Size	**5-9**	**2-10**	**2-10**	**4-20**	**-**	**-**	No Limit	No Limit	**5-12**	**2-12**
Project Size	All	Small	All	Large	All	All	All	Small	All	Small
Iteration duration (weak)	**4**	**2**	**-**	**2**	**-**	**2**	Contingent	**4-8**	**1-2**	Contingent
Roles	√	√	√	√	**X**	**X**	√	√	√	√
Process Focus	√	**X**	√	√	√	√	**X**	**X**	√	**-**
People Focus	√	√	**X**	**X**	**X**	**X**	√	√	√	√
Virtual Team Support	√	**X**	**X**	√	**X**	√	√	√	**-**	**-**
Risk Mitigation	**X**	√	**X**	√	√	√	**X**	**X**	√	**-**
Documentation	Initial	Initial	√	Important	**X**	**X**	Important	Initial	Initial	Initial
Daily Meeting	√	√	**X**	**X**	**X**	√	**X**	√	√	**-**
Information Sharing	**X**	**X**	√	√	**X**	**X**	**X**	**X**	**-**	**-**
Face to Face Meeting	**X**	**X**	**X**	**X**	√	**X**	√	**X**	√	√
Model Orientation	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	√	**X**

Those teams preferred to develop agile and team-based practices that fit their specific needs over technical practices and defined methods (Julian, Brendan, James, & Craig, 2019). The main focus of this research is on team layer and it is not customized for data management.

In the "Is Kanban a more suitable agile approach in highly regulated environments?" report published by Deloitte, It is claimed that the use of agile practices for developing products or performing operational tasks is becoming more popular and the tendency to digitalization and workflow automation has led to the adoption of lean and agile practices (Heil, 2022).

Considering the current market environment, companies may choose between different agile practices to produce goods and providing intangible services. All these approaches have the same general principles, including:

- Empirical methods with formal feedback loops;
- Pull principle and Works in Progress (WIP) control;
- Continuous process improvement.

According to this article, despite Scrum and Kanban's similarities, there is a key difference between them and you should know them before deciding which approach to take:

- Scrum focuses on iterative product development;
- Kanban focuses mostly on monitoring and improving the work flow that the usage team is dealing with. In this method, heavy effort is put into visualizing and training the team about flow, measuring performance and quality.

In rigidly enforced environments, companies should establish the right balance between uncertainty management and regulatory compliance. These environments

mainly focus on implementing mandatory process steps and quality control.

While Scrum and other scaled practices come with a set of pre-defined activities and roles, Kanban approach is being built on your existing practices to slowly and very systematically improve them. Kanban starts with your existing roles as it respects the legacy system value. It means changing roles or formal staff qualifications/training are less needed and, if necessary, it's less stressful. This is a significant advantage, especially in highly regulated environments where roles and procedures are very stable and tend to resist ad-hoc changes (Heil, 2022). This practice has also a comparative approach and is not customized for data management and does not consider scalability.

Reviewing the research backgrounds, it can be concluded that most of the agile related studies have a comparative approach and are not equipped with a scalable and customized agile framework for data management discipline. Some studies considered the concept of agile in data management or merely deal with a specific area of data management such as data warehouse and data production which lacks a comprehensive look at data management throughout the data life cycle or do not come up with a practical, customized and scalable framework.

3. Method

The dominant paradigm of this research is data-orientation, agile manifesto and lean thinking. The purpose of this research is applied and developmental and it is qualitative inherently. Data collection method is library research, and the required tools for data collection are documentary study, Expert Panel and field observation. Because of the complexity and Interdisciplinary essence of the problem, Reasoning, analogy and exploration through Design Science Research Methodology (DSRM) are used to make a conclusion. The customized methodology is presented in Figure 4.

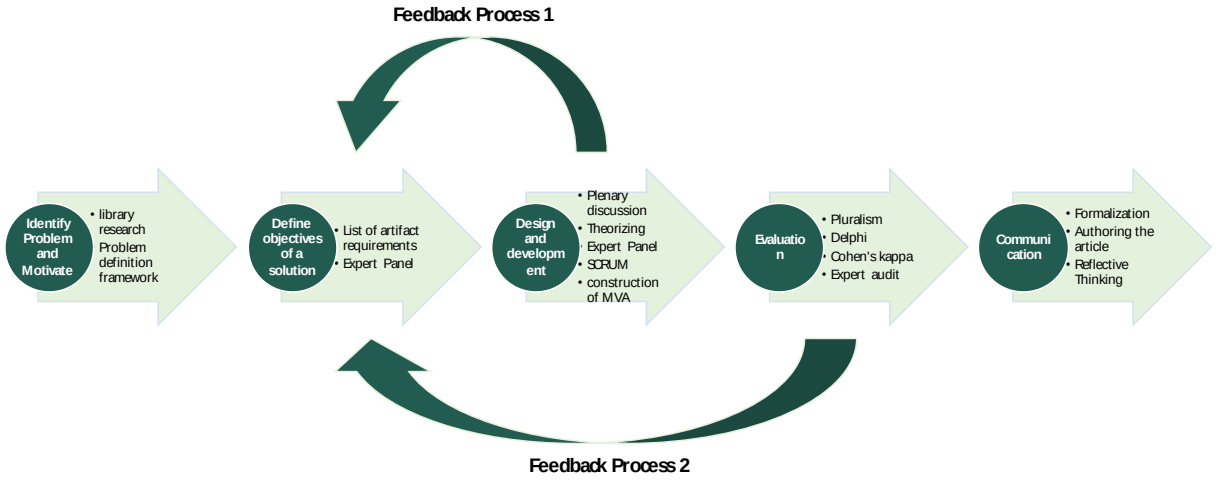

Figure 4 . *The research methodology is derived from the DSRM model of Peffers et al., 2007 (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007)*

First step: Identify Problem and Motivate

In the first step of design science method, an initial understanding of the research concepts was obtained using reliable international scientific databases, and to ensure that all aspects of the problem are covered, using an Expert Panel consists of seven experts in the fields such as: Data Management, Software Engineering, Knowledge Management, Enterprise Architecture Management and Agile Project Management who were selected using a convenience sampling method available in Iran. Finally, by using the researchers' field experiences, past researches, related theories, frameworks and international valid standards and any other related popular Reference Models were recognized, and then the boundaries and problem definition framework were defined for data management with scalable agile approach. The output was recognizing the concepts related to data management, agile and scalability, as well as discovering new

categories such as lean thinking and common agile practices.

As shown by the findings of (Legner, Pentek, & Otto, 2020) Knowledge accumulation occurs in stages as a result of maturing abstract and situational domain knowledge (solution space), and in response to evolving data roles (problem space). So the Problem definition framework is organized in three stages:

- **The First Phase:** Ontology - The period between 2006 and 2007:

Framing the problem and creating a common understanding of data management at the enterprise level.

- **The Second Phase:** Creating capabilities - the period between 2008 and 2014:

Assessing maturity and building required data management capabilities.

- **The Third Phase:** Change of orientation - from 2015 until now:

Addressing the growing data needs of digital and data-driven enterprises.

On the other hand, according to the study of (Wiraeus & Creelman, 2019) it has been proven the need to adopt an agile approach in the strategic management of business initiatives, so the fourth phase of knowledge aggregation could be titled Agile Data Management. In the same direction and according to the consensus of expert's opinion, the problem definition framework was organized in two dimension: Problem space and Solution space.

Table 2 *- Problem Definition Framework*

Phase	Phase 1: Ontology	Phase 2: Capability Building	Phase 3: Reorientation	Phase 4: Agile Manifesto
Time Period	2006-2007	2008-2014	2015-2019	2019- Present
The Problem Space				
Research questions	• What is enterprise-wide data management? • What are its constituents (nature, boundaries, rationale)?	• How does one build enterprise-wide data management capabilities? • How does one assess the data management's maturity (implementation)?	• What is data management for digital and data-driven enterprises? • What are changes to the artifacts from Phases 1 and 2 (boundaries, rationale, implementation)?	• How to be agile in data management and strategic value creation? • How can data intelligence be increased?
Boundaries	• Master data	• Master data	• All data types	• All data types
Nature	• Enterprise-wide (quality-oriented) data management	• Enterprise-wide (quality-oriented) data management	• Enterprise-wide (strategic) data management	•Enterprise/Departmental/ Team (agile strategy) data management
Rationale	• Data quality	• Data quality	• Data excellence	• Data as a product
Implementation	-	• Data management capabilities and maturity levels	• Continuous improvement	• Iterative and gradual lean and agile methods
The Solution Space				
Artifacts	• Initial version of the reference model (alpha version of generic artifact)	• Refinement of the reference model: maturity assessment and refinement of design areas via methods, tools, and guidelines	• Reorientation and revision of the reference model (beta version of generic artifact): modification and extension of maturity assessment and design areas via methods, tools, and guidelines	• Agile embedding in the reference model (generic artifact gamma version); Reforming and expanding the conceptual and operational system of the general artifact
Instantiations	• Mainly expert feedback (artificial evaluation methods), or explication of emerging situational design	• Company-specific instantiations (situational design)	• Company-specific instantiations (situational design), or explication of emerging situational design	• the emergence of strategic initiatives based on agile methods, the need for agility in feeding smartness with data

Second Step: Define Objectives of a Solution

As the second step, based on the different dimensions of the problem defined first, an initial list of goals that should be considered for the artifact was defined and how the artifact helps to solve the problem was reviewed with the opinion of experts. In this way, a list of artifact specifications as meta-requirements as well as considerations for artifact design in the form of design decisions and artifact characteristics were identified and organized from the four perspectives of ontology, capability creation, reorientation, and agility as described in the Figure 5.

The different versions of the artifact reflect the accumulation of design knowledge through changes in the problem space (meaning Meta-requirements) and solution design (meaning design decisions and the structure and content of the artifact). To design the desired artifact, we need 9 key design decisions (DD) that answer 13 requirements. These design decisions and meta-requirements represent the changing spaces of the problem and solution from 4 perspectives. The mapping between the identified requirements and the key design decisions required according to the opinion of experts is shown in the Figure 5.

Third Step: Design and Development of Artifact

The third step is about designing and developing based on the analysis and combination of previous studies through an iterative approach. Here it is tried to use the methods of design and creative thinking, along with presenting a framework based on the research background and theoretical fields, also an illustrative comparison is done in order to compare the existing definitions with the structure and definitions of this framework and expressing its generalizability (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). In this step, design and development process was conducted by Plenary discussion, theorizing in expert panel and constructing artifact through Scrum method. In this way, at the beginning of this step, previous related theories, research,

reference models and any related international standards from academic knowledge base reviewed in order to explicate (Implicit) design knowledge. After theoretical saturation. the results were shared with the expert panel. Then, the expert panel began to theorize, discuss and exchange opinions about meta-requirements, design decisions and alternative solution design. In the end of the first sprint according to consensus of expert panel members the initial Minimum Viable Artifact (MVA) was designed and constructed. This MVA was reviewed through a plenary discussion as a sprint review with more than 10 experts in the field of information technology from different industries. The feedbacks were delivered to expert panels for more discussion and confirmation of design decisions.

Due to the need for constant improvement of the suggested framework during the SCRUM method, this framework was reviewed and improved by expert panel in four sprints to find the best alternative solution design. The final artifact which is inspired by 18 references consisting of Reference Models, Standards, International Guides, and Theories is presented as a conceptual model in the Figure 6. In order to clarify our framework, the selected references were added in the form of horizontal and vertical axis.

As a main decision for designing the artifact, according to, according Levitt's enhanced theory, the axial elements of the suggested framework includes people and organization, process and practice, technology and data management capability. Also, to design scalability levels, project management principles used to consider three levels of portfolio, program and project. Finally, according to the scalability level proper agile practices are identified.

Fourth step: Evaluation of Artifact

Although before this step, iterative unstructured plenary discussion with experts and also evaluation of artifact by expert panel have been done during each sprint review in order to continuously improve the artifact, after obtaining the necessary satisfaction of the expert panel regarding the quality of the artifact, evaluation by other methods is also used to ensure validity and reliability. For this purpose, the methods of comparing the artifact with the predetermined requirements and design decisions for the artifact, as well as conducting a Delphi method regarding the experts' satisfaction with the validity and reliability of the artifact have been used.

In simple words, the evaluation has been done in two dimensions for the artifact:

1- The dimension of results evaluation (internal validity): to answer the question whether the results and findings were in line with the goals of the research or not. This evaluation has been done with the help of receiving feedback by Delphi method from two subject matter experts in the field of data management.

2- Reliability assessment dimension (internal reliability): to answer the question of whether the activities, tools and techniques of methodology used in the right manner. This evaluation was done with the help of calculating Cohen's kappa coefficient by distributing a checklist (consisting of a questionnaire including 12 questions taken from the stages of research and methodology) and getting feedback from two experts. The calculated Cohen's kappa coefficient value is estimated around 0.83 which considering the complexity of the concept is purely satisfying.

Fifth Step: Communication of Artifact

As a last step, the final step is to publish and present the findings, which has been done in the form of writing this article and future articles and translating a book in the field of agile, and has invited other researchers to apply and think reflectively about the findings of this research, in order to develop the application, promote and continuously improve the presented framework.

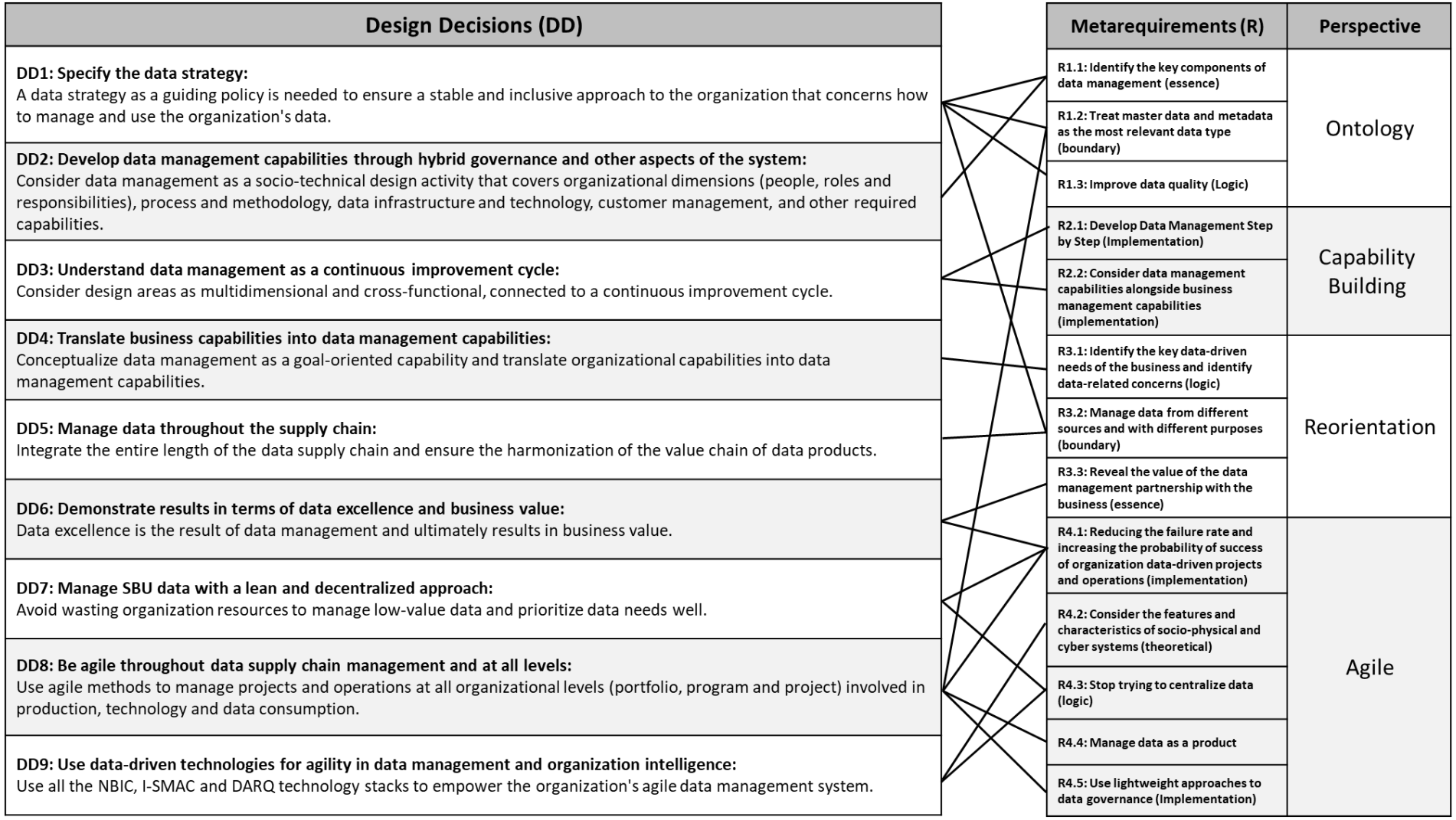

Figure 5*. Mapping of Artifact Metarequirements and Design Decision*

4. Findings

In fact, the results of this research show the extent of the added value the framework suggested in this study adds to each of the definitions, frameworks and standards reviewed. The issue of data management is an interdisciplinary concept, so this is a wicked problem. There are various reference models for the concepts of agile, data management, Information System and Software Engineering, but few of them practically embedded agile practices in a scalable management system, despite the remarkable importance of agility in the optimal data management of social-physical-cyber systems today. So there is an essential need to design a comprehensive model

Our suggested framework is based on the final sprint of design step, adapting project management standards and information, including three levels of Portfolio, Program, and Data Lab, and inspired by Levitt's theory, which was updated by Gold, Harper, and Katz in 2023. The main elements of the model are categorized into four groups: people and organization, agile process and practice, technology and knowledge areas (Gold, Harper, & Katz, 2023). Here it is intended to design & present a scalable conceptual framework of combining agile practices along with the main elements of a data management system named Scalable Agile Data Management Framework (SADMF), based on the raised topics and the research background comparison, and also based on a set of logical arguments. This framework is shown in **Figure 6**. Next, we will describe the architecture and components of this conceptual framework.

The architecture of the suggested framework consists of three levels as agile portfolio management, agile program management, and agile data lab, which are designed based on lean thinking (Origins and History of Lean, 2023). These layers are influenced by the sixth edition of the PMBOK guide ((PMI), 2017) (version 4.5 of the SAFe framework is also modeled after this guide (SAFe, 2018)), according to this standard, organizational initiatives and projects should be able to be planned, executed, monitored, controlled and terminated at each of the three levels of portfolio, program and project (Andriole, 2018).

The components of each level as evaluation units can be classified into four groups of people and organization, agile process and practice, technology and knowledge areas of data management according to their essence.

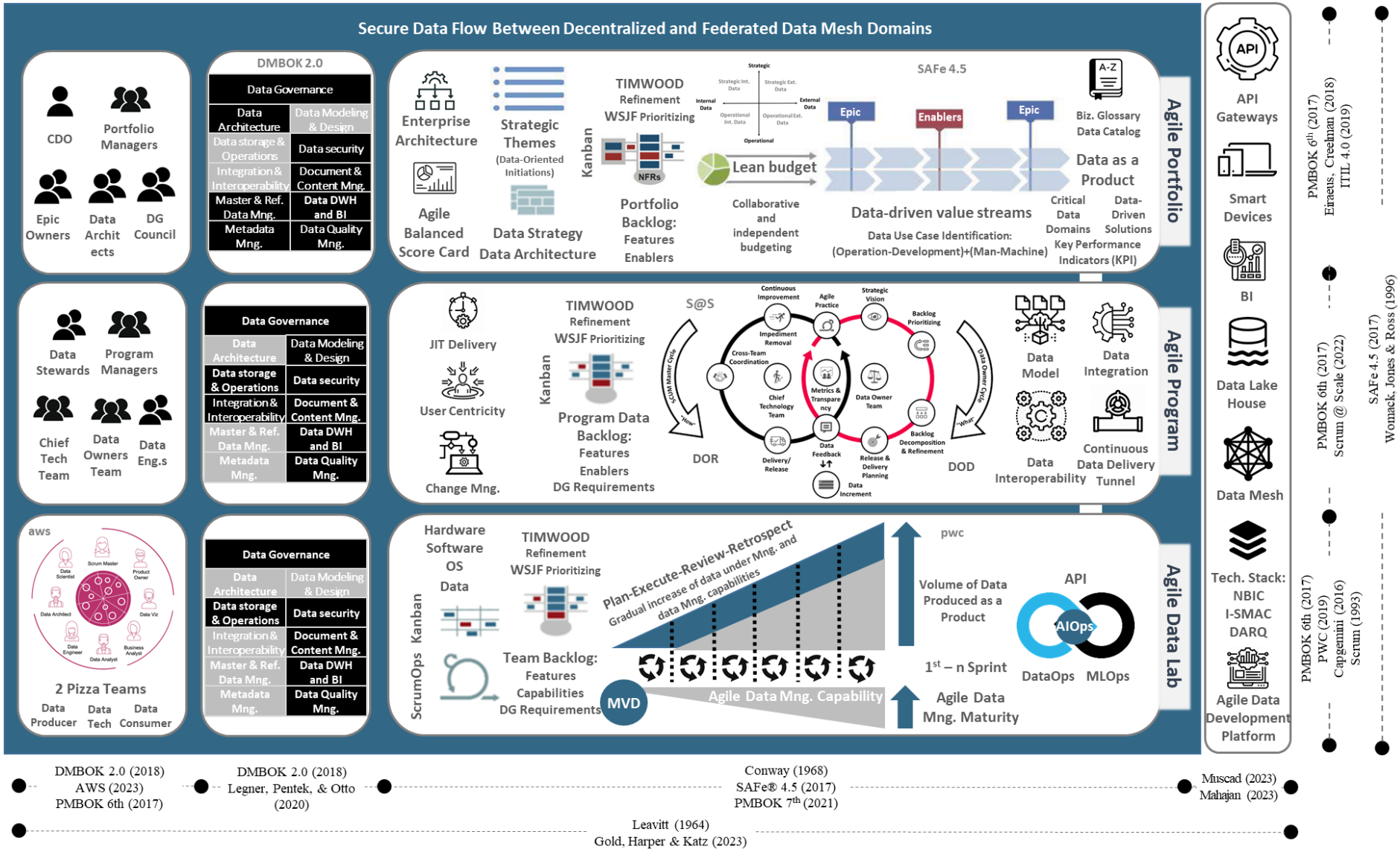

***Figure 6**. Suggested Framework for Scalable Agile Data Management (SADMF)*

People and Organization Element

The design of this element is influenced by sources of (DAMA, 2009), (The Modern Data Community, 2023) and ((PMI), 2017). This element includes the people of an organization and the competencies or mindsets that must be cultivated in them to succeed. The organizational structure also allows them to split responsibilities and work together efficiently and agilely. People in your organization are responsible for doing a part of data management or wrapping up a related project in an agile manner. This includes an agile structure of people who carry out tasks, managers and leaders who organize the entire data management efforts and make decisions about key points, or stockholders who drive companies towards their goals.

At the team (project) level, it is called Agile Data Lab in the framework. Team members are actually the same 2 Pizza Teams specialized as scrum master, product owner, data illustrator, business analyst, data analyst, data engineer, data architect, and data scientist. Here the sources are ((PMI), 2017), (PWC, 2019), (Capgemini, 2015) and (Schwaber & Sutherland, 2020).

At the program level, it is called agile program management in the framework. People at this level may include roles such as program managers, data stewards, data engineers, data owners' team, and senior data technology team. The sources at this level are ((PMI), 2017), (Sutherland, 2022) and (SAFe, 2018).

At the portfolio level, it is called agile portfolio management in the framework. People at this level may include roles such as portfolio managers, agile data governance council members, data architects, epic owners, and CDOs. The sources used at this level include ((PMI), 2017), (Wiraeus & Creelman, 2019) and (ITIL Foundation 4th edition, 2019).

Process Element and Agile Practice

To design this element, we're influenced by sources (Odusola, 2023), (SAFe, 2018) and also ((PMI), 2017). This process is the starting point that aligns people with the culture and quality of work required in a project or initiative. You need specific processes in order to lead teams via the right procedures and protocols during task implementation. In this framework, it is suggested that the process groups required for the management of knowledge areas to be designed according to the industry and business type, and the teams should have authority in designing the task forming processes and the procedure of implementing the agile practice, as due to the work scope ambiguity, it is recommended that teams to choose tasks and work packages with authority. In fact, the process groups and main processes are the guide for people and teams. According to the evaluation, the suggested agile practices in each framework level are:

At team (project) level, it is called Agile Data Lab in the framework. The recommended agile practices to succeed at this level are Kanban and ScrumOps, which are enhanced with lean techniques such as TIMWOOD and WSJF. These practices, as explained in Table 1, are chosen based on SAFe framework and emphasizing the findings of PWC and Deloitte.

At the program level, it is called agile program management. The recommended agile practices to succeed are Kanban and S@S, which are enhanced with lean techniques such as change management, TIMWOOD and WSJF. This practice is suggested, due to its integrity and proper differentiation between managerial and technical categories in agile management and according to Sutherland study (Sutherland, 2022) which verifies technical and managerial dimensions differentiation in the AWS research (The Modern Data Community, 2023).

At the portfolio level, it is called agile portfolio management in the framework. The recommended agile practices to succeed are Kanban and Agile Balanced Score Card (Agile BSC), which are reinforced with lean techniques such as lean budgeting, TIMWOOD and WSJF. These practices are derived from the SAFe framework and are picked based on the findings of PWC and Deloitte due to the highly sensitivity and influence of decisions and organizational strategic themes.

Technology Element

(Mahajan, 2023) and (Muscad, 2023) sources were applied to design this element. Technology refers to the tools and systems we use to support & authorize our people to perform processes more efficiently and agilely. Today, technology has become the focal point of organizational transformation across data-driven industries. New tools can be a substantial investment. These substantial investments face noncompliance of the organizational people, so they need to be managed optimally through appropriate design, senior management support, promoting people digital maturity, and most importantly, facilitating and strengthening the agility of people and processes.

Therefore, technology must be properly evaluated, implemented and applied. The main focus of the suggested framework is on the use of decentralized, federated and distributed technologies such as Agile Data Development Platform, Data Mesh, and also Data Lake against centralized technologies such as Data Warehouse. In choosing technological tools and techniques, the focus is on choosing technologies that emphasize integrating with operations, technologies such as: DataOps, MLOps, AIOps, APIOps. Taking into consideration that the ultimate goal of data orientation is intelligence, it is necessary to use the group of intelligent technologies like I-SMAC, NBIC, DARQ matching the technological theme of the industry.

Data Management Field of Knowledge Element

(DAMA, 2009) and (Legner, Pentek, & Otto, 2020) sources were applied to design this element. A knowledge area is an identified area of a management system defined by its knowledge requirements and described in terms of processes, practices, inputs, outputs, tools and techniques ((PMI), 2017). In the suggested framework, according to the generality and acceptability of the DAMA-DMBOK 2.0 guide, this framework is chosen as the main reference for choosing data management knowledge areas (DAMA, 2009). This guide introduces eleven knowledge areas of data management, including the following knowledge areas:

1. **Data Governance:** Establishing policies, procedures and standards to ensure effective and consistent management of data across the organization.
2. **Data Architecture:** Designing and maintaining data infrastructure to support data integration, data quality, and data access.
3. **Data Modeling and Design:** Defining data structures and relationships to support business processes and goals.
4. **Data Storage and Operations:** Ensuring effective & safe data storage supporting data availability and performance.
5. **Data Safety:** Protecting data against unauthorized access, disclosure or misuse and ensuring compliance with applicable regulations.
6. **Data integration and interoperability:** Integrating data from different sources and ensuring that data could be exchanged and used in different systems.
7. **Document and Content Management:** Managing unstructured data, such as documents and multimedia content, to ensure accessibility, accuracy and compliance.
8. **Data Warehousing and Business Intelligence:** Storing, analyzing and presenting data to support intentional decision making.
9. **Metadata Management:** Collecting, storing and managing information about data, such as data origin, definitions and classifications.
10. **Data Quality Management:** Ensuring the accuracy, integrity, timeliness and compatibility of data with business requirements.
11. **Master and Reference Data Management:** This knowledge area enables organizations to understand operational data and effectively analyze different collected data.

5. Discussion

Today, we're facing the most mature level of cybernetic systems rushing towards intelligence. Benefiting from the utmost abstraction and the big data volume, these social-physical-cyber systems have created chaotic and complex systems which demand

agility to deal with. These systems are inherently complex, ambiguous and transformative, and they can only be managed through data management, which is no longer feasible through the old classical and predictive methods. It is now inevitable to change our point of view and go for new agile practices. In fact, choosing the right agile practice out of various agile practices is not an easy task, according to Spotify, to be really lean and agile, we have to design a customized agile practice for the context and the requirements of our desired solution.

In this research, influencing by globally acclaimed frameworks and standards and using science and design methodology, we tried to provide a customized and more importantly scalable framework aiming to manage data in an agile way. This framework is designed on a scalable view by incorporating data management and agile concepts through an iterative approach. The suggested framework includes three macro layers as agile portfolio management, agile program management and agile data laboratory and it consists of four groups of main elements including people and organization, agile process and practice, technology and data management knowledge areas. Modeling this framework is recommended to those organizations and businesses which are willing to cope with more agile intelligence. Given that, due to the selected methodology, the research process has been repetitive, the suggested framework might be constantly upgraded through more iterations in future researches.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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