Journal of Universal Computer Science, vol. 29, no. 1 (2023), 34-72
submitted: 17/12/2021, accepted: 19/10/2022, appeared: 28/1/2023

A Maturity Model for Digital Business Ecosystems from an IT Perspective

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Abstract: Digital transformation impacts longstanding business models and enables enterprises to create new ones. This transformation leads to increased competition that forces enterprises to compete, not only between companies but also between the entire supply chain and business networks. The emerging concept of digital business ecosystems (DBE) allows enterprises to concentrate on network co-creation and co-evolution of bundled services and products across enterprise boundaries. This exploratory study introduces a maturity model derived from existing DBEs. Based on employing a design science methodology, we reviewed 22 scientific publications, interviewed 28 senior experts from practice and derived a maturity model from the results. We applied the maturity model through an online survey to 29 DBEs from different industry sectors and compared it with 22 maturity assessment approaches from other domains. The maturity model enables researchers to compare and assess existing DBEs and helps practitioners to identify areas for improvement in the collaboration within DBEs.

Keywords: Digital business ecosystems, Maturity models, Enterprise architecture management
Categories: H.0, H.1.0
DOI: 10.3897/jucs.79494

1 Introduction

The ongoing phase of digital transformation impacts industry today by enhancing existing business models and providing opportunities for new ones [Venkatesh et al., 19]. The race to exploit these opportunities leads to increased competition [Horlach et al., 16], not only between companies but also between entire supply chains and networks. Therefore, enterprises are forced to align their Business and IT with stakeholders across companies' borders [Vargas et al., 13]. The discipline to support and improve these Business-IT alignments is Enterprise Architecture Management (EAM) [Maes et al., 00, Farwick et al., 16]. Generally speaking, EAM is responsible for transforming a company's "as-is" IT landscape into a "to-be" IT landscape following an enterprise's business strategy. New technologies such as the Internet of Things allow enterprises to establish new bundled or hybrid business models that combine services

and products from different providers [Iivari et al., 16]. These technologies enable the concept of digital business ecosystems (DBE), which affects traditional industry boundaries for organizations to compete and collaborate through digital technology [Senyo et al., 19a, Faber et al., 19]. DBEs allow enterprises to shift their concentration to network co-creation and co-evolution of bundled services and products. Within DBEs, every involved enterprise is self-organized in its business processes and EAM [Senyo et al., 19a, Hedges and Furda, 19]. Researchers [Selander et al., 13] define DBEs as a collective of firms or organizations connected by a shared interest in the prosperity of digital technology with the objective of materializing their own product or service innovation. The success of such companies as Alibaba, Amazon, Uber, and Airbnb outlines the potential of DBEs [Floor, 06, Smith, 16, Hajibaba and Dolnicar, 18]. There is still uncertainty as to how DBEs start, grow, develop, become extinct, and renew themselves [Jansen et al., 19]. Moreover, there is evidence [Senyo et al., 19a, Jansen et al., 19, Senyo et al., 19b] that a lack of maturity regarding practices in the organization of a DBE exists.

Research [Gupta et al., 19, Tsatsou et al., 10, Kraus et al., 19] discusses essential aspects such as regulatory issues or the meaning of trust within DBEs. The authors of [Lenkenhoff et al., 18] describe key challenges concerning stakeholders' role-related issues. They highlight the general need for a coordinating and governing function to achieve mature DBE's. Also, the work of [Hedges and Furda, 19] concludes that there will be an emerging role of an Ecosystem Architect. This role may arise from the formerly known role of Enterprise Architect. It can add significant value in ecosystems' early stages by governing strategy development and analyzing the key strategic implications and risks. However, many researchers [Senyo et al., 19a, Jansen et al., 19, Pidun et al., 19, Senyo et al., 19b, Ehrensperger et al., 20] identified research gaps within DBEs. In general, there is a lack of case studies [Senyo et al., 19a, Senyo et al., 19b] reflecting the practitioner's perspective from existing DBEs among different industries. Besides, [Senyo et al., 19b] identified that existing literature does not clearly distinguish between DBE maturity levels. This identification reveals a lack of two components. (1) The definition of maturity levels and (2) the maturity assessment of existing DBEs within the industry. The authors also noted the development of a theoretical basis and models of DBEs as a current research gap [Senyo et al., 19b]. Moreover, the authors [Hedges and Furda, 19, Tan et al., 09] outlined that a DBE reaches different maturity levels during its evolution but left open how these levels are defined and how DBEs are assessed. These gaps reveal that the research does not sufficiently cover the definition and assessment of the maturity of existing DBEs.

In order to address these gaps, we based our investigations on the design science methodology [Hevner, 07]. Our contribution comprises the practitioner's insights by conducting expert interviews (EI) and an online survey along with a Systematic Literature Review (SLR) considering scientific attainments regarding DBEs. Since the deployment of a maturity model enables maturity assessments [Vallerand et al., 17], we use these results to develop, apply, and evaluate a maturity model for DBEs. The maturity model aims at providing transparency to achieve an understanding of the maturity of DBEs. It allows practitioners to position their as-is DBE and guides them on further improvements. Moreover, it provides transparency to research how DBEs emerge and which maturity levels they surpass.

The scope of DBEs is extensive, but we determined that existing research investigates them primarily from two perspectives: a business perspective (e.g., [Senyo

et al., 19a, Namugenyi et al., 19, Van Alstyne et al., 16]) and an IT perspective (e.g., [Jansen et al., 19, Lenkenhoff et al., 18, Somaye et al., 17]). Research from the business perspective elaborates on topics such as business opportunities resulting from DBEs, their strategic meaning, and business models that complement each other. The IT perspective focuses on transforming the IT landscape by managing technologies, development efforts, process designs, and required governance activities of DBEs. However, both perspectives are inextricably interwoven. We decided to focus on the IT perspective in this study to achieve a greater scientific depth. To that end, we defined the following research question:

- RQ1: Which dimensions and maturity levels should be included in a model to measure the maturity of DBEs?
- RQ2: How can the maturity model be applied to existing DBEs, and what is the added value for practitioners?
- RQ3: What are the maturity model's benefits compared to existing approaches for maturity assessments in related domains?

In researching this paper, we reviewed 22 scientific publications, interviewed 28 senior experts from practice, and designed a DBE maturity model from the results. We applied this maturity model to 29 DBEs from 14 different industry sectors and compared it with 22 other maturity assessment approaches from related fields. In doing so, we extend our previous work [Ehrensperger et al., 21] on exploring DBEs' maturity.

The remainder of this paper is structured as follows: Section 2 discusses related work. In section 3, we outline the applied research methodology. Section 4 develops a DBE maturity model, and section 5 discusses our results and provides answers to our research questions. Finally, section 6 concludes the paper and provides an outlook on future work.

2 Related work

Related work can be classified into four categories: (1) analysis of DBEs from a business perspective, (2) analysis of DBEs from an IT perspective, (3) maturity model research, and (4) publications outlining maturity of DBEs.

Concerning (1) the analysis of DBEs from a business perspective, we identified five studies. The authors of [Namugenyi et al., 19] designed an analysis to identify the strength, weaknesses, opportunities, and threats (SWOT) of DBEs. They define a list of sequential steps that examine the business, industry, and market from various DBE stakeholder perspectives. Following these steps yields information to guide business managers in strengthening their DBE strategies, business execution, and control. In [Van Alstyne et al., 16], the authors investigate the DBE's impact on business strategies and digital platforms and describe reciprocal effects between producers and consumers, such as the spillover effect. The spillover effect is explained using the example of Uber [Floor, 06]. An individual ride mediated by Uber delivers to both sides of the market; it is easier for consumers to get rides and for drivers to find fares. This two-side market supply is facilitated through DBEs. Therefore, the authors foresee a pivotal role for DBEs in future business. An analysis of network effects of DBE platforms is described by [Gawer and Cusumano, 14]. The authors emphasize that these effects in DBEs are more impactful compared to traditional supply chains of separated enterprises. These effects result from positive feedback loops, especially those directly between the DBE

platform and the user. For instance, Amazon [Budzinski and Köhler, 16] attracts users, friends of users, and friends of friends of users; all of these users have different needs that can be satisfied via the same DBE platform and therefore lead to powerful network effects. Wieringa et al. [Wieringa et al., 19] provide insights into the business-IT alignment problem of network organizations. Within network organizations, business-IT alignments cannot be hierarchically coordinated due to the lack of a central coordinator with final responsibility. Thus, new approaches are needed, which the authors investigate. They provide a modeling framework to enable the identification of such alignment problems. Zrenner et al. [Zrenner et al., 19] investigate options to enable data sovereignty for critical business data within DBEs. DBE supply chains are usually extended due to the focus on the co-creation of bundled products and services among multiple enterprises. Therefore, participating enterprises fear losing critical business data to third parties through their DBE participation. To address this concern, [Zrenner et al., 19] provides 12 architecture options that meet different data sovereignty requirements, which gives guidance to DBE managerial responsibilities.

We also identified related literature investigating (2) DBEs from an IT perspective. The work of [Lenkenhoff et al., 18] investigates interoperability and actor-related challenges of DBE developments. In doing so, the authors compare two DBE development approaches: top-down and a bottom-up. They argue that both approaches may provide significant benefits for DBEs as well as disadvantages. Tan et al. [Tan et al., 09] develop a process model based on the example of Alibaba.com. This model illustrates how a DBE may be developed and leveraged for enterprise agility. Their study outlines how Alibaba.com was developed over the last two decades and concludes that the DBE development nature changed from a hub-and-spoke ecosystem (a DBE with a dominating center) to a networked ecosystem (a loosely coupled value-creating network) and then into a symbiotic ecosystem in which the entire DBE functions as a single entity utilizing pooled resources and capabilities. Transforming DBEs toward a cloud-based architecture was investigated by [Korpela et al., 16]. DBE cloud integrations are expected to offer a cost-effective and interoperable opportunity for small and medium-sized enterprises to participate. Therefore, the authors categorize the readiness and the importance of DBE functionalities such as the service portfolio toward cloud integration using an example from industry. In so doing, they provide a DBE framework that enables business managers to determine user requirements for cloud service integrations. Moreover, their findings suggest that DBEs should establish a knowledge-sharing base to accelerate cloud integrations. [Mueller et al., 13] investigates the ability of the well-known EAM framework TOGAF (The Open Group Architecture Framework) to address the diverse challenges of inter-organizational collaboration. The authors review existing literature and conclude that TOGAF may support tackling DBE challenges in the areas of process, data, infrastructure, and application integration. Finally, the authors hypothesize that other EAM frameworks, such as the Zachman Framework [Iyamu, 18] or ARIS [Scheer, 12], have scopes that are too narrow to take advantage of improvements in the area of facilitating DBEs. If so, researchers must agree on a suitable extension of these frameworks.

We also investigated existing **(3) maturity models**. In doing so, we recognized that maturity models are a well-known and longstanding assessment approach for determining maturity. In the 1970s, [Gibson and Nolan, 74] founded this concept by describing a model to control information systems' performance. Since then, various maturity models have been designed to describe certain phenomena in research. The

literature reviews [Santos-Neto and Costa, 19, Merkus et al., 20, Wendler, 12] investigated maturity model usage. [Merkus et al., 20] and [Wendler, 12] analyzed existing literature in a similar way and distinguished maturity model usage in domains (e.g., governmental domain), areas (e.g., business process management area), and enterprise segments [Santos-Neto and Costa, 19] (e.g., software engineering). They emphasize that maturity models need application-specific constructions to fulfill their purpose. Moreover, none of the reviewed maturity models focus on DBEs.

Only a few researchers partly highlighted **(4) the maturity of DBEs**. The first steps were done by [Korpela et al., 13] when DBEs were at a quite early stage. Their work describes a framework for exploring DBEs, which they developed from Zachman's enterprise architecture. This framework serves as a basic structure for exploring the value network within DBEs. Senyo et al. [Senyo et al., 19a] focus on the political will in DBEs and the socioeconomic benefits of DBEs. They suggest a framework that also partially considers the maturity of DBEs. However, their research focuses on state organizations rather than on enterprises. Furthermore, it provides only a vague description of the meaning of maturity. Hedges and Furda [Hedges and Furda, 19] describe the emerging role of an ecosystem architect. They also highlight changing maturities of DBEs over their lifecycle but leave open how maturity levels are defined and how these can be assessed.

These findings reveal that it is unclear how the maturity of DBEs can be defined and assessed by researchers and practitioners. To the best of our knowledge, there is no exploratory study investigating the definition and assessment of the maturity of DBEs. Moreover, we could not identify any maturity model that focuses on DBEs.

3 Applied Research Methodology

According to the authors [Becker et al., 09] and [Mettler, 09], the design of a DBE maturity model falls into the area of the design science research methodology [Hevner, 07]. Appendix A.18, inspired by [Hain and Back, 11, Geerts, 11], illustrates the applied design science research steps, including its comprising research methods and our undertaking activities.

In the following sections, we discuss the research methods in detail. In doing so, section 3.1 explains the expert interview, section 3.2 the systematic literature review, and 3.3 the online survey.

3.1 Expert Interview

We carried out the expert interview (EI) to initiate the design science research according to [Hevner, 07]. Therefore, we conducted semi-structured expert interviews based on the general instructions of [Wohlin et al., 12] and their advice to consider guidelines provided by [Fink, 03]. We let us inspire by these authors since [Wohlin et al., 12] is a widely respected researcher in software engineering and [Fink, 03] provides us with detailed guidelines matching the needs of the study at hand. These expert interviews should investigate the practitioner's perspective on the maturity of existing DBEs and identify requirements for designing the artifact. Section 3.1.1 explains the EI design, section 3.1.2 describes the selection of participants, and section 3.1.3 outlines the analysis procedure.

3.1.1 Expert Interview Design

We carried out the EIs between May and July 2020. In designing the expert interviews, we followed [Gläser and Laudel, 09] and derived interview questions from the research question RQ1 accordingly. In doing so, we structured the interview questions so that the sequence of questions introduced the participants to the topic and made it more comprehensible to them [Kaiser, 14]. This structure facilitates a more natural understanding of the interview [Kaiser, 14]. Table 1 depicts these interview questions and the mapping to their IQ ID.

IQ ID	Interview Questions
IQ1	Can you describe the DBE in your environment?
IQ2	Can you describe the co-evolution process of a DBE and the project portfolio planning among separated enterprises within a DBE?
IQ3	How are innovations in DBEs promoted and managed?
IQ4	Can you outline the expected benefits of this DBE?
IQ5	Which needs in the management of DBEs are not addressed? Can you also outline the challenges?
IQ6	How would you define different levels of maturity which you passed along the setup of the DBE?

Table 1: Overview of interview questions

We provided three different documents with the interview. First, in advance of the interview, the experts received preliminary information containing a description of the research and the interview's intention. Second, during the interview, an interview protocol was maintained with personal information such as the years of experience in EAM, and third, the research protocol lists all interview questions, and the given answers were recorded. We list these three interview documents in appendix A.7. The interview itself was conducted via Skype or phone.

3.1.2 Participants

We defined two selection criteria to find eligible interview participants: (1) employment in the field of EAM within a DBE and (2) at least five years of professional EAM experience with IT focus. Moreover, we selected the participants according to their membership in EA-related forums within the social networks LinkedIn [Chang et al., 17] and Xing [Buettner, 16]. In total, we contacted 94 experts, with 28 experts willing to participate in the interview. The interviewees participated voluntarily and were distributed across 12 countries. Moreover, the participants worked mainly in a senior role in the field of EAM within medium to large-sized organizations of multiple different industries. The average level of experience was about 11.9 years. Appendix A.1 outlines further details regarding the participants.

3.1.3 Analysis of the Interview Results

We analyzed the interviews according to the method described by [Mayring, 10], which guided us on paraphrasing, coding terminologies, generalizing to a higher abstraction

level, and reducing the given answers to their core ideas. This method allowed us to cluster the given answers and to recognize which participants gave similar ones. Our coding followed an inductive procedure. Once more than one participant described the same topic, we created a category (e.g., perceived DBE challenges) according to this procedure. This approach was required to analyze the qualitative questions. In doing so, we used the software tool MAXQDA [Rädiker and Kuckartz, 19] and followed an inductive coding procedure. We coded a category (e.g., maturity characteristics) when more than one participant gave the same answer to a specific question. This procedure yielded various categories that let us recognize relevant DBE aspects such as a general conspectus, perceived challenges, and maturity characteristics.

3.2 Systematic Literature Review

We carried out the SLR to determine the availability of existing knowledge, theories, or artifacts [Kitchenham et al., 09, Kitchenham and Charters, 07] and, in doing so, to guarantee that the produced design is a research contribution and not a routine design based upon the application of well-known artifacts [Hevner, 07]. Applying this method has the advantage of a higher degree of confidence in covering the relevant literature compared to informal literature reviews. Moreover, using the procedure described in [Kitchenham et al., 09, Kitchenham and Charters, 07] minimizes subjectivity and bias. The following section, 3.2.1, explains the systematic literature review design, including the search strategy and search process, and section 3.2.2 outlines the result analysis procedure.

3.2.1 Systematic Literature Review Design

We designed the SLR according to the guidelines by Kitchenham et al. [Kitchenham et al., 09]. We followed these guidelines by defining a search term, identifying relevant literature, and presenting the results. This literature review aims at investigating the research questions RQ1, RQ2, and RQ3. We carried out this literature review between the middle and end of October 2020 and finalized it in December 2021. To determine the relevant literature, we divided the publication selection process into three phases, as depicted in Appendix A.9. In the following, these three phases are explained in more detail.

In Phase 1, we selected the most important scientific databases [Cavacini, 15] in computer science. These are, together with the corresponding number of retrieved publications, shown in Appendix A.14. To cover a broad set of articles, we used the search term (Maturity Model AND Digital Business Ecosystem) to identify the relevant publications. We selected these keywords since it circumscribes the research questions addressed scope. Moreover, we considered all publications where the keywords appeared somewhere in the articles. In total, this procedure led to a summary of 8163 publications.

In Phase 2, we applied the inclusion and exclusion criteria by reading the title, keywords, and abstract of the publications. Appendix A.15 illustrates these inclusion and exclusion criteria. We investigated articles that were accessible in full text, available in English or German, that highlighted maturity models in the context of digital transformations and introduced a maturity model for a dedicated purpose. Since the first seminal paper distinguishing DBEs from other business ecosystems was

published in 2010 by [Stanley and Briscoe, 10], we have decided to analyze existing literature from that date onwards. Since the selected scientific databases may index similar studies and a single search could retrieve identical primary studies, we have excluded duplicates. Furthermore, to ensure the quality of each study, we excluded gray, white, and workshop literature together with publications that discuss maturity only in a general manner. This procedure led to 42 remaining publications.

In Phase 3, we continued applying the inclusion and exclusion criteria by reading the entire publication. This procedure led to 18 relevant publications dealing with maturity models in the context of digital transformations. Using the remaining 18 publications as a foundation, a snowballing literature search [Wohlin, 14] was conducted. The reference list of each of the remaining publications, as well as their citations, were reviewed for further relevant articles. A further four relevant articles met our inclusion criteria and were added to our sources list.

Moreover, we further ensured the publication quality by applying evaluation criteria according to [Alves et al., 10]. Appendix A.16 shows the questions we raised to assess the study's aim, rigorousness, credibility, and relevance. The publications had to meet each of these criteria to remain. In doing so, every publication was analyzed by two authors of this publication. Once an author disagreed on a particular classification, the publication's content was discussed until consensus could be attained. We applied this approach also in the subsequent review result analysis. Afterward, we extracted relevant data to answer the research questions. The extracted data are the following: the scope, the analysis dimensions, the number of maturity levels, the method of maturity model definition, -evaluation, and -application. We added the full list of identified publications and their analysis results to appendix A.6.

3.2.2 Analysis of the Review Results

Classification taxonomies enable readers to gain an exhaustive understanding of analyzed literature [Hansman and Hunt, 2005]. Therefore, we developed the following classification taxonomy to analyze the remaining 22 publications according to [Usman et al., 17]. The methodology of [Usman et al., 17] contains four steps: **(1) planning**, **(2) identification and extraction**, **(3) design and construction**, and **(4) validation**.

In **(1)**, we established the plan to design the taxonomy with respect to our research questions. Hence, we drew in **(2)** different dimensions and categories from literature. We did this by discussing and iteratively defining categories according to the following procedure. A new category was defined whenever more than a single source addressed a specific topic. Finally, in **(3)**, we designed the entire taxonomy and **(4)** validated it by classifying the publications. Appendix A.10 illustrates the classification taxonomy. As a result, we highlighted the **maturity models' scope** and recognized that these scopes could be categorized in related fields. Therefore, we categorized them into

- **digital transformations**,
- **change management**,
- **Industry 4.0**, and
- **software ecosystems**.

Digital transformations contain models reflecting an enterprise digital transformation's maturity. Change management summarizes all publications assessing an organization's general maturity in their established change management (e.g., startup ecosystems). Industry 4.0 aggregates publications that are assessing DBE-relevant

maturity topics such as the digitalization of separated value chains across multiple enterprises (e.g., logistics) and software ecosystems that can be seen as a technological foundation for DBEs since they enable the construction of large software systems [Jansen, 20].

We investigated the **analysis dimensions** of the described maturity models and synthesized them into categories. We did this categorization according to the following approach, once more than one maturity model contained the same or similar analysis dimension, we created a category. This procedure resulted in the following categories:

- **knowledge management**,
- **innovation**,
- **technology**,
- **process**,
- **market access**,
- **culture**,
- **governance**,
- **strategy**,
- **expandability**,
- and a category for maturity models that only consider a **single analysis dimension**.

In the following, we explain these dimensions in more detail. In knowledge management, we added publications assessing an organization's maturity concerning the acquisition, sharing, and leveraging of knowledge towards individual business goals. Innovation includes papers that assess maturity in facilitating, sharing, and organizing innovations. Technology includes publications that assess an organization's technology's maturity, related to its adaptability, capability, and business value. The category process summarizes publications investigating an organization's business processes' maturity regarding its management and control. Market access comprises publications outlining an organization's maturity to penetrate markets and sell its services and products. Moreover, the category culture contains publications reflecting an organization's cultural maturity regarding mindset and mentality towards achieving its goals. Governance includes publications scrutinizing an organization's maturity concerning its leadership, structures, processes, and financial planning to sustain its objectives. The category strategy aggregates publications emphasizing the maturity of business and IT strategies regarding its policies, formalization, coordination, roles, roadmap, and goals. Expandability adds publications representing an organization's maturity to expand services, products, data, processes, technologies, and innovations. Finally, the category single analysis dimension summarizes a publication with only one single dimension.

Our analysis also includes the **number of maturity levels**, which we classified into

- **three-**,
- **four-**,
- **five-**,
- **six-**,
- and **eight-level** categories.
- In addition, we added the category **rating score**,

which includes maturity models that deliver a maturity rating score instead of predefined maturity levels. This score delivers a value between 0 and 1.

Besides, we categorized the used **methods for defining the maturity model**, which we sorted into the derivation from

- **literature**,
- the derivation from **expert interviews**,
- and the derivation from **literature & expert interviews**.

We investigated the **evaluation methods of maturity models**, which allowed us to categorize them into

- **multiple case studies**,
- **single case studies**,
- **feature comparison**,
- **multiple case studies**,
- and **no evaluation at all**.

Moreover, we highlighted the **maturity models' application methods** and distinguished between

- **semi-structured interviews & a questionnaire**,
- **a survey based on a predefined questionnaire**,
- application through a **software program**,
- and **no application at all**.

3.3 Online Survey

We conducted an online survey to apply and evaluate the designed maturity model. We chose a survey examination design according to [Wohlin et al., 12] to receive feedback from DBEs out of multiple industry sectors (multiple case study). In doing so, we used the Goal-Question-Metric (GQM) [Caldiera and Rombach, 94] approach to design a questionnaire that supports an accurate application of the maturity model. We conducted an online survey to deploy the designed questionnaire. We selected the GQM approach since it enables a straightforward application of the maturity model with a questionnaire's help. This questionnaire aims at achieving an objective measurement of DBEs' maturity. This approach allows researchers to manage complexity when there are many attributes to measure and to promote consensus about the objective measurement of the maturity of DBEs. The application of the GQM approach offers several advantages for an objective measurement of DBEs' maturity levels. It ensures the adequacy, consistency, and comprehensiveness of the measurement [Raju and Uma, 14]. Appendix A.8 illustrates the approach we follow. The GQM approach contains three phases [Basili and Rombach, 88, Van Solingen and Berghout, 99]. These are the (1) planning & definition, (2) information collection, and (3) interpretation phase. These steps are described in the following.

3.3.1 Planning and Definition Phase

In the planning and definition phase, the GQM approach [Basili and Rombach, 88] requires the determination of the goal, the purpose, the issue, and the object for its deployment. As a goal, we seek to attain the maturity of Digital Business Ecosystems (object). Therefore, we measure (purpose) the issues of transparency, standardization, reusability, knowledge base, cybersecurity, expandability, and governance. Besides, we determined different viewpoints on the measurement goals [Basili and Rombach, 88]. Consequently, we derived the following three components from TOGAF [Thorn, 07]:

Business Architecture, Information Systems Architecture, and Technology Architecture. These components represent viewpoints, which we integrated into the GQM approach. Also, we added the viewpoint "Other" to allow the participants to state individualized viewpoints. Appendix A.11 summarizes our determinations. As foreseen in the GQM [Basili and Rombach, 88] approach, we defined the GQM questions and GQM metrics, which we illustrate in appendix A.5. In doing so, we considered authors who researched the respective issues by determining the GQM questions, such as [Levstek et al., 18] and [Baffoe and Luo, 20].

3.3.2 Information Collection

To collect the required information, we carried out an online survey with the tool LimeSurvey [Klieve et al., 10] between November and December 2020. This survey contained the defined GQM questions. Furthermore, we selected the participants according to the same selection criteria as in our first EI, described in section 3.1.2: (1) employment in the field of EAM within a DBE and (2) at least five years of professional EAM experience with IT focus. Before publishing the survey, we conducted a pilot run that was filled out by five EAM experts. Afterwards, we adapted the GQM questions slightly according to their suggestions. In the next step, we published the final version of the survey in online forums on LinkedIn [Chang et al., 17] and Xing [Buettner, 16] that deal with EAM. 29 experts that work within DBEs were willing to take part in the survey. In conducting the survey, 12 of them did not finalize the entire survey. Finally, 17 experts completed the entire survey, whereby nine of them were also part of the expert interview (section 3.1.2). The experts participated voluntarily and were located across the globe in seven different countries. Moreover, the participants were already senior in EAM with an average experience level of 11.35 years. The participants chose a wide range of viewpoints, besides the derived TOGAF [Thorn, 07] viewpoints, also individual ones such as Enterprise Architect and IT Infrastructure Management. This study represents all the different size categories of organizations in terms of employees. Appendix A.2 outlines the participants in more detail.

3.3.3 Interpretation Phase

To interpret the resulting values from the GQM metric, we map these values to certain levels, as shown in Table 2. A discussion concerning the accurate maturity level design will be done in the following sections.

GQM Metric	**Maturity Level**
0 % – 20 %	Level 1: Initial
20 % - 40 %	Level 2: Managed
40 % - 60 %	Level 3: Defined
60 % - 80 %	Level 4: Quantitatively Managed
80 % - 100%	Level 5: Optimized

Table 2: Mapping of GQM Metrics to Maturity Levels

4 Developing a DBE Maturity Model

This section illustrates the results of developing the DBE maturity model. Therefore, we structure this section according to the applied design science methodology steps, as described in appendix A.18. Section 4.1 discusses the motivation and identifies the initial problem, section 4.2 defines the solution requirements, section 4.3 designs the maturity model, section 4.4 applies the maturity model, and section 4.5 evaluates the maturity model.

4.1 Motivation and Problem Identification

This section describes the motivation of forming a DBE. In doing so, it explains the results of our EI by providing a general DBE conspectus (section 4.1.1) along with the perceived DBE challenges (section 4.1.2). The second step provides the results of our SLR by discussing the existing literature's limitations (section 4.1.3). Finally, the section ends with determining the research problem (section 4.1.4). For better readability, we outsourced the participant's references from sections 4.1.1, 4.1.2, and 4.2.1 to appendix A.17.

4.1.1 General Conspectus of DBEs

To establish a general conspectus of DBEs, our EI asked the participants to explain the DBEs of their current work. The analysis of these explanations led to three main categories of DBEs. (1) Governments are initiating DBEs among federal authorities, municipalities, and private enterprises. (2) Holdings are organizing DBEs with the enterprises within their holding structure. (3) Independent enterprises are jointly establishing DBEs. In the following, we describe one example for each category and outline its current status.

(1) DBEs in governmental environments: For instance, P4 outlined a DBE initiated by the Swiss government [eOperations, 21]. This DBE allows swiss residents to register a change of place of residence with an online service. This online service includes features such as a target address validation, a request for a new vehicle registration plate, required tax adjustments, and automatic post redirection. This DBE comprises different public authorities, such as communities, cities, federal provinces (cantons), national institutions, and private enterprises.

(2) DBEs within a holding structure: P6 explained a DBE example embedded into the company's holding structure. In the past, this company was operating in a telecommunication business, including the provisioning of internet services and mobile networks. The holding initiated a DBE to act as a cloud provider for their different legal entities to develop their business further. Moreover, the holding offers different services such as IaaS (Infrastructure as a Service), Voice over IP (Internet Protocol), Voice over WLAN (Wireless Local Area Network), or functionalities for streaming television that can be used, enhanced, and adapted from their legal entities. An example is an affiliate company in a country that is willing to start a new TV service (streaming television) based on a new TV platform. It can reuse standard functionalities provided such as cloud resources, network resources, and existing content (movies, series), whereby third-party providers offer the content. The content of the TV platform is integrated through additional services.

(3) DBEs among independent enterprises: P13 highlighted a DBE example named Open Banking [Brodsky and Oakes, 17] that comprises competing and non-competing enterprises out of the financial industry. Open Banking enables different service providers to access accounts and customer information of a bank to provide value-adding attainments. For instance, FinTech companies [Arner et al., 15] offer solutions to access multiple accounts and stock portfolios from different banks via a single-entry point. A further use case is that banks can make customer recognition through online video identification services. The customer can authenticate via face recognition services offered by third-party providers to carry out financial transactions. Within this DBE, an enterprise can offer its services and also consume other services without any central instance.

4.1.2 Perceived Challenges

Our EI analysis also focused on the perceived DBE challenges to identify the research problem. Therefore, we categorized the participant's answers into *(1) challenges on the strategic level*, *(2) challenges on the technical level*, and *(3) challenges on the skill level*.

(1) challenges *on the strategic level*: **Differing interests** make it challenging to create win-win situations for all participants, was the challenge most often cited. **Protecting an enterprise's intellectual property** is also perceived as a challenge. Since in DBEs, not only cooperating but also competing enterprises are participating, the preservation of intellectual properties such as insights on customer information, business strategies, and expert knowledge is perceived as problematic. Apart from this, the **strategy alignment** among different enterprises concerning commonly offered services, products, and the corresponding budget planning, the definition of KPI's and incentives to achieve a common goal were stated as a challenge. Moreover, **segregated responsibilities** are a hindrance in improving overlapping business processes. The area of **decision making** is seen as challenging since it is not clear on which level and with which partner the decision needs to be aligned. Furthermore, the potential **vendor-lock-in effect** of DBEs was explained. Once enterprises integrate their services and products into a shared portfolio, they risk losing their capability to act independently on the market. This challenge may lead to a **loss of control** of their assets, market visibility, and steady customers. The **scope alignment concerning customer demand** becomes challenging. Enterprises usually concentrate on their customer group and try to satisfy their demand. Thereby, the project scope's alignment to fulfill various customer demands of a DBE is perceived as a challenge. The **limitation of entrepreneurial freedom within DBEs** is stated as a challenge since, for every extension of shared products and services, alignment and joint agreement needs to be achieved. The **risk of making the wrong investments** through the incorrect selection of partner enterprises and third-party services was also highlighted. The emerging DBEs lead to **more market competition** since competing enterprises can more and more easily participate in already established DBEs.

(2) challenges on the technical level: A missing **holistic view of the entire DBE** was emphasized, which is related to the complexity of commonly capturing the shared platforms, security, compliance, infrastructure components, and people's interaction within a model. Through growing DBEs, also the number of **linked dependencies** of systems and processes is growing. These dependencies bear the problem if a central

system or service crashes, since multiple business transactions, and enterprises are impacted. The participants highlighted **different timelines** on the implementation level among enterprises as a challenge. Also, **the lack of aligned and used standards** of interfaces and information objects such as the structure and details of business partner information are emphasized as challenges. Some participants expressed a **missing centralized IT** of DBEs as a challenge. Every IT governance activity needs to be steered decentralized, which causes extra efforts for the enterprises. **Information security** is also seen as a challenge. Since the enterprise's interactions require a considerable number of interfaces and shared platforms, the challenge of missing overarching information security was highlighted. Also, some DBEs struggle with **missing collaboration tools**, such as document management tools. The **legacy system compatibility** was a challenge for enterprises within a DBE.

(3) challenges on the skill level: The participants also outlined a **lack of common understanding** as challenging. This lack emerges from the differing use of terminologies, focuses, and scope among the participating enterprises. Moreover, a lack of **know-how** is seen as a challenge. Since the requirement on DBEs' technology and business capability knowledge is growing, additional knowledge transfers need to be considered. Finally, closely connected to the former, is the challenge of **complexity** resulting from growing DBEs.

4.1.3 Literature Limitations

Through our SLR, we analyzed literature to find existing literature's limitations. We identified that none of the existing maturity models allow an assessment of DBE maturity. Moreover, we found it is decisive for DBEs to get a holistic view (section 4.1.2) involving all DBE-relevant aspects to assess maturity. This missing assessment capability is related to the model's 1.) differing scope, 2.) a lack of DBE aspects, 3.) to vague results, and 4.) different purposes.

For 1.), we analyzed their scopes and recognized related but not exactly matching scopes (e.g., [Cukier et al., 20, Mohamed, 20, Kreiling and Bounfour, 19, Donker and van Loenen, 17, Enkel et al., 20, von Solms and Langerman, 21, Lin and Wang, 21, Gökalp and Martinez, 21a, Gökalp and Martinez, 21b]). For 2.), we doubt that the described criteria, dimensions, and aspects (e.g., [De Carolis et al., 17, Cancian et al., 20, Azevedo, 19]) are fully appropriate for reflecting DBE maturity. For 3.), it is questionable (e.g., [Werner and Kosacka, 19, Adrodegari and Saccani, 20]) whether the results are precise enough to compare existing DBEs and to derive specific improvement measures. For 4.), the purpose of the analyzed models differ. Some models' purpose is to investigate manufacturing firms' (e.g., [Rafael et al., 20, Wagire et al., 20, Lin et al., 20, Gökalp and Martinez, 21a]) maturity, while others (e.g., [Saputra et al., 19, Gollhardt et al., 20, Jansen, 20, Alves et al., 11, Cukier and Kon, 18]) aim to investigate software ecosystemic, digital transformations, or CRM-related circumstances.

Nevertheless, none of the models exactly address the purpose of determining maturity, enabling comparing and assessing existing DBEs. However, the models may be partially relevant in terms of their analysis dimensions, maturity levels, definition-, application-, and evaluation approaches. Therefore, we foresee using them as existing literature knowledge in our further investigations.

4.1.4 Problem Identification

To identify the underlying research problem, we extract the problem's relevance and provide an accurate problem definition in the following sections 4.1.4.1 and 4.1.4.2.

4.1.4.1 Problem Relevance

The increasing competition [Venkatesh et al., 19, Horlach et al., 16] that forces enterprises to compete between entire supply chains and business networks initially disclosed the problem's relevance. As a result, enterprises increasingly strive to form or participate in DBEs. These findings let us conclude that the problem's relevance is increasing since the number of publications addressing the topic's field seems not solving the identified challenges (section 4.1.2). Moreover, we could identify the expectation that **participating in DBEs will play a crucial role for enterprises in the future**. The participants (P7, P9, P10, P16, P17, P18, P19) explained that expectation with the following arguments. Since businesses require constant and fast adaption to changing market demands, DBEs help enterprises improve their competitiveness. Through DBEs, enterprises may focus on their core competencies while satisfying their customer demands holistically. Therefore, the participants (P7, P9, P10, P16, P17, P18, P19) see DBE participation as highly relevant for their enterprises.

4.1.4.2 Problem Definition

We revealed that the industry lacks mature DBEs, which is outlined by the various identified challenges (section 4.1.2). Behind the term, a lack of mature DBEs, the participants understand that DBE enterprises poorly tackle the described challenges. Moreover, our SLR findings (section 4.1.3) outline that **no maturity model that comprehensively analyzes the DBE-relevant dimensions exists,** despite **maturity models appearing to be an emerging and essential topic**. The problem can be narrowed to a 1.) missing definition of DBE maturity, and a 2.) missing assessment opportunity, which enables 3.) comparisons among participating enterprises.

4.2 Definition of the Solution Requirements

This section narrows and defines the solution requirements based on the EI and the SLR results. In doing so, the EI identified DBE maturity characteristics (section 4.2.1), which provides us with the first solution requirements. Besides, our SLR recognized maturity analysis dimensions (section 4.2.2), the number of maturity levels (section 4.2.3), maturity model definition (section 4.2.4), application (section 4.2.5), and evaluation (section 4.2.6) approaches, considered in related fields. These gained SLR results help us define the solution requirements and later on evaluate the designed maturity model. Finally, this section will end up with the derived design objectives.

4.2.1 Maturity Characteristics

To identify the solution requirements, our EI asked the participants how they would distinguish between different maturity levels of DBEs. In doing so, the participants explained characteristics that enable us to assess DBE maturity. Simple **expandability** was seen as vital since it allows DBEs to include new enterprises. **Joint governance** gives guidance and can make decisions concerning a common DBE strategy. **Extended security and data privacy** are required to detect vulnerabilities in a DBEs' distributed

landscape. A central data privacy function assuring compliance with GDPR (General Data Protection Regulation) [Voigt and Von dem Bussche, 17] standards to distribute personal information among different enterprises is perceived as valuable. Moreover, a continually maintained **DBE knowledge base** that learns with the evolving DBE is seen as vital. Also, the **reuse of existing services**, platforms, and software solutions were highlighted as a maturity characteristic. The degree of **standardization** of deployed software solutions, business processes, and interface technologies is seen as another maturity aspect of DBEs. **Transparency** on dependencies that comprise a particular overarching business process was highlighted as crucial.

4.2.2 Clustered Analysis Dimensions

Our SLR investigated the analysis dimensions considered in maturity models from related fields to provide us with knowledge concerning the existing analysis dimension's content, allowing us to build our solution design thereon. Since the model's scopes differ significantly, we could identify a wide range of diverse analysis dimensions. Therefore, we decided to synthesize these dimensions and reduce them to their central focus. In doing so, we followed [Walsh and Downe, 05], which outlines a synthesis method to determine how studies are related, or dissonant, through a compare and contrast exercise. As a result, we could synthesize the range of considerations into ten different clustered analysis dimensions, as shown in appendix A.3. We summarized dimensions assessing intellectual property such as patents and licenses of an enterprise within the clustered analysis dimension **knowledge management**. Moreover, we created cluster **innovation**, which includes dimensions that deal with improvement proposal management topics and dimensions that assess how enterprises foster innovation. The cluster **technology** is established to accumulate the dimensions assessing maturity issues in terms of software development processes, deployed technology, and technology operational activities. Moreover, we defined the cluster **processes** to count analysis dimensions that assess the business processes' maturity in various business units such as logistics management, maintenance management, production management, and engineering. The cluster **market access** was created to add dimensions that assess marketing management's maturity, such as campaign management, product offerings, and sales strategies. We added dimensions such as entrepreneurial thinking and transparent communication that fosters effective collaboration within the cluster **culture**. The cluster **governance** includes dimensions that assess leadership and organizational structures' maturity within an enterprise. Moreover, the cluster **strategy** summarizes dimensions assessing an enterprise's implementation policy, coordination activities, and formalization. **Expandability** accumulates dimensions considering the capability to extend ecosystems, including technological capabilities and the general openness to expanding. Finally, we added the cluster, **monolithic dimensions,** to summarize publications [Werner and Kosacka, 19, Alves et al., 11] that are not distinguished explicitly between different analysis dimensions.

As a result, it is visible that the most frequently represented clusters are governance, technology, and culture. The less frequently represented clusters are monolithic dimensions, expandability and market-access. We foresee using the content of these analysis dimensions in our further work.

4.2.3 Number of Maturity Levels

Our SLR investigated the number of maturity levels within the maturity models from related fields. The majority of papers derived the levels from CMMI [Somaye et al., 17], which uses five different levels. We grouped the papers [Saputra et al., 19],[Gollhardt et al., 20],[Werner and Kosacka, 19],[Rafael et al., 20],[Alves et al., 11],[De Carolis et al., 17],[Cancian et al., 20],[Kreiling and Bounfour, 19],[Lin et al., 20],[Donker and van Loenen, 17],[von Solms and Langerman, 21],[Lin and Wang, 21],[Gökalp and Martinez, 21a] and [Gökalp and Martinez, 21b] into this five-level category. Moreover, several authors decided to implement a three-level based maturity model such as [Adrodegari and Saccani, 20], [Mohamed, 20], and [Cukier and Kon, 18]. The publications [Wagire et al., 20] and [Cukier et al., 20] used a four-level metric, [Enkel et al., 20] a six-level and [Jansen, 20] eight-level metric. Finally, [Azevedo, 19] used a metric that can attain a maximum value of 1, a minimum value of 0, and 99 intermediate values.

4.2.4 Definition Approaches

Our SLR also highlighted the applied research method to define the maturity model used in related fields. Using this information allows us to find the best-in-breed approach to design our maturity model. Therefore, we distinguish the used methods in (1) derivation from expert interviews, (2) derivation from literature, and (3) derivation from expert interviews and literature.

The paper [Cukier and Kon, 18] defined its maturity model with the help of expert interviews (1). The majority of papers [Saputra et al., 19], [Rafael et al., 20], [Alves et al., 11], [De Carolis et al., 17], [Mohamed, 20], [Kreiling and Bounfour, 19], [Lin et al., 20], [Donker and van Loenen, 17], [Azevedo, 19], [Enkel et al., 20], [von Solms and Langerman, 21] and [Lin and Wang, 21] derived their maturity models from literature (2). Also, a significant part of the authors [Gollhardt et al., 20], [Werner and Kosacka, 19], [Jansen, 20], [Adrodegari and Saccani, 20], [Cukier et al., 20], [Cancian et al., 20], [Wagire et al., 20], [Gökalp and Martinez, 21a] and [Gökalp and Martinez, 21b] derived their maturity models from expert interviews and literature (3).

4.2.5 Application Approaches

Our SLR analyzed the maturity model's application approaches from related fields to find the optimal application method. This analysis lets us conclude we can categorize in an application with (1) semi-structured interviews and a questionnaire, (2) survey based on a predefined questionnaire, (3) application by a software program that analyzes input parameters, and (4) no application at all.

The authors who applied semi-structured interviews (1) are [Saputra et al., 19], [Gollhardt et al., 20], [Rafael et al., 20], [Jansen, 20], [Cukier and Kon, 18], [Adrodegari and Saccani, 20], [Cukier et al., 20], [Cancian et al., 20], [Donker and van Loenen, 17], [Gökalp and Martinez, 21a] and [Gökalp and Martinez, 21b]. Moreover, the authors of [Werner and Kosacka, 19], [Alves et al., 11], [De Carolis et al., 17], [Kreiling and Bounfour, 19], [Wagire et al., 20], [Lin et al., 20], [Azevedo, 19] and [Lin and Wang, 21] applied a survey (2). One author [Mohamed, 20] applied a software program, which analyzes input parameters for its maturity model application (3). Finally, the authors of

[Enkel et al., 20] and [von Solms and Langerman, 21] did not apply their maturity model at all (4).

4.2.6 Evaluation Approaches

For being able to evaluate our maturity model accurately, our SLR studied the applied evaluation methods from related maturity models. Therefore, we categorize them in (1) feature comparison, (2) single case study, (3) multiple case study, and (4) no evaluation at all.

We add the publications [Gollhardt et al., 20] and [Gökalp and Martinez, 21b] in (1) since they evaluate its maturity models based on a features comparison. Moreover, the authors of the papers [Saputra et al., 19], [Werner and Kosacka, 19], [Rafael et al., 20], [Alves et al., 11], [De Carolis et al., 17], [Cancian et al., 20], [Wagire et al., 20], [Donker and van Loenen, 17], and [Azevedo, 19] evaluated their maturity models by a single case study (2). Several authors [Jansen, 20], [Cukier and Kon, 18], [Adrodegari and Saccani, 20], [Cukier et al., 20], [Kreiling and Bounfour, 19], [Lin et al., 20] and [Gökalp and Martinez, 21a] evaluated their maturity models with the help of a multiple case study (3). Finally, the authors of [Mohamed, 20], [Enkel et al., 20], [von Solms and Langerman, 21] and [Lin and Wang, 21] did not conduct any evaluation at all (4).

4.2.7 Design Objectives

This section describes the solution objectives (section 4.2.7.1) and outlines the corresponding evaluation (section 4.2.7.2).

4.2.7.1 Solution Objectives

Inspired by general maturity model capabilities [Vallerand et al., 17], this maturity model aims to assess the maturity of DBEs from an IT perspective. Moreover, it should enrich researchers and practitioners in the following: For researchers, our maturity model should enable comparing and assessing existing DBEs. In doing so, it should provide transparency to understand how DBEs emerge and which maturity levels they surpass. For practitioners, it aims at helping to identify areas for improvement in the collaboration within DBEs by also considering different IT practitioner perspectives. Moreover, it should be applicable straightforwardly and quickly provide the assessment results.

4.2.7.2 Evaluation

In the following, we determine evaluation allowing us to measure the fulfillment of the described solution objectives. In doing so, we structure the evaluation according to the design science methodology [Becker et al., 09], which states that an evaluation must include assessing an artifact's 1.) usefulness, 2.) quality, and 3.) effectiveness.

To address 1.) the usefulness, we applied the maturity model by carrying out an online survey based on the GQM-approach (section 3.3). In doing so, we follow the suggestions of [Becker et al., 09], which proposed expanding the empirical basis in developing a web page enabling employees to calculate the degree of maturity. This approach allowed us to retrieve statistical feedback on the maturity distribution within different industry sectors. Furthermore, we added the questions FB1 and FB2 to the online survey (Appendix A.5). To assess 2.) the quality of our maturity model, we

added the questions FB3, FB4, FB5, and FB6 to the online survey. For example, these questions highlight whether any maturity model dimension is missing or an existing one is not helpful. The evaluation of 3.) the effectiveness of the maturity model is a crucial and highly complex endeavor at the same time [Alves et al., 11, von Wangenheim et al., 10, Helfert et al., 12]. Moreover, such an evaluation requires a long period of time [Alves et al., 11], which is difficult to achieve, especially for novel topics, such as DBEs. Therefore, a complete effectiveness evaluation is currently not yet feasible. However, for a partial effectiveness evaluation, we distinguish between a) the effectiveness of the maturity model design, -definition, -application, and -evaluation approach along with b) the effectiveness of the maturity model itself. For 3a.), we will compare our maturity model with other existing approaches from related fields to address RQ3. In doing so, we adapt the classification taxonomy based on the gathered knowledge base (sections 4.2.1 - 4.2.6). This adaptation was required since hereinafter we want to compare different maturity models instead of publications very precisely. Figure 1 depicts this adapted classification taxonomy.

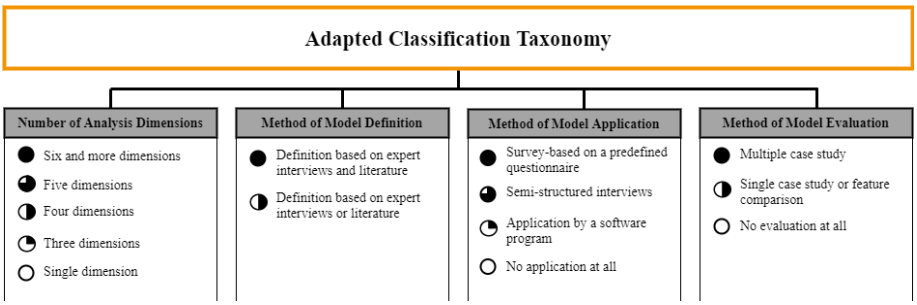

Figure 1: Adapted Classification Taxonomy

We defined the following comparison parameters (1) number of analysis dimensions, (2) method of model definition, (3) method of model application, and (4) method of model evaluation. Moreover, we developed a metric where we outline the potential values with the following symbols ○,◔,◑,◕, and ●. This approach enables us to visualize the results of the adapted classification taxonomy deployment. We benchmark the number of analysis dimensions (1) based on the results in section 4.2.2. Moreover, we categorize the maturity model definitions method (2) by considering the results of section 4.2.4. The results of section 4.2.5 enable us to compare the method of maturity model application (3). Finally, we juxtapose the maturity model evaluation methods based on the outcome of section 4.2.6. For 3b.) it would require a long-term study to observe whether a DBE transforms itself according to the maturity model's suggestions [Helfert et al., 12]. Since DBEs may comprise large and distributed enterprises, observing such transformations may last for a more extended period. In order to achieve a partial evaluation, we added the question FB7, addressing the maturity model's effectiveness, to the online survey (Appendix A.5).

4.3 Design of the DBE Maturity Model

Our findings provide us with the required maturity characteristics (section 4.2.1) to design DBE maturity dimensions (RQ1). Moreover, our investigations (sections 4.2.1

- 4.2.6) revealed **how maturity models from related fields are designed**, building the basis for answering RQ2 and RQ3. As the next step, we design the DBE maturity model in this section. Since the SLR revealed, no DBE maturity model exists, but models from related fields partially address relevant dimensions, we decided on the following design approach. According to the design science methodology [Hevner, 07], the artifact's design should be based on existing knowledge and, at the same time, focus on the environmental requirements (DBEs). Therefore, we synthesize the maturity characteristics identified by the EI (section 4.2.1) and content of maturity dimensions identified by the SLR (section 4.2.2), which match or cover each other (e.g., joint governance and governance). This synthesis is done in a way that also includes tackling DBE challenges (section 4.1.2) in its target design (e.g., segregated responsibilities need to be tackled by joint governance to achieve higher maturity). This design approach was made according to the principles of [Tan et al., 20, Pöppelbuß and Röglinger, 11], which provides guidance in ascertaining and measuring dedicated aspects of technical and social systems maturity. Figure 2 illustrates this design approach and outlines the defined maturity dimensions.

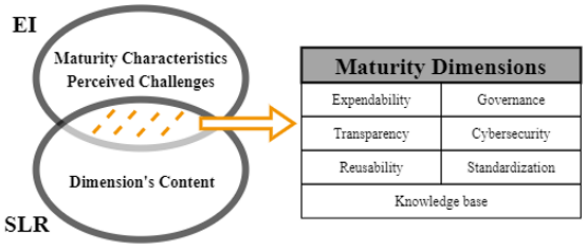

Figure 2: Derivation of the Maturity Dimensions

Moreover, the majority of participants either described (P3, P7, P11, P13, P17, P19, P20, P21, P23, P24, P25, P27) maturity levels with a remarkable resemblance to CMMI (Capability Maturity Model Integration) [Somaye et al., 17] or explicitly recommended (P5, P9, P10, P12, P14, P28) adopting CMMI maturity levels for DBEs. Also, the SLR results (section 4.2.3) illustrated that most maturity models from related fields adopted a five-level CMMI approach. Using the CMMI approach bears the following DBE-relevant advantages [Alfaraj and Qin, 11, Lina and Dan, 12, Tsai, 21, Flores-Rios et al., 20, Palomino et al., 17]: 1.) fosters minding a comprehensive view, while focusing on improvement of specific details, 2.) encourages continuous improvements due to its repeatable usage design, 3.) provides a common framework supporting efficient communication, 4.) provide a standardized output and, therefore, enable comparison-based evaluations, 5.) is widely known and supported by practitioners. Therefore, we decided to design the maturity levels accordingly. Our interview results let us conclude that a DBE is moving sequentially through the proposed levels from the lowest level 1 to the highest level 5. The following Figure 3 illustrates the DBE maturity model.

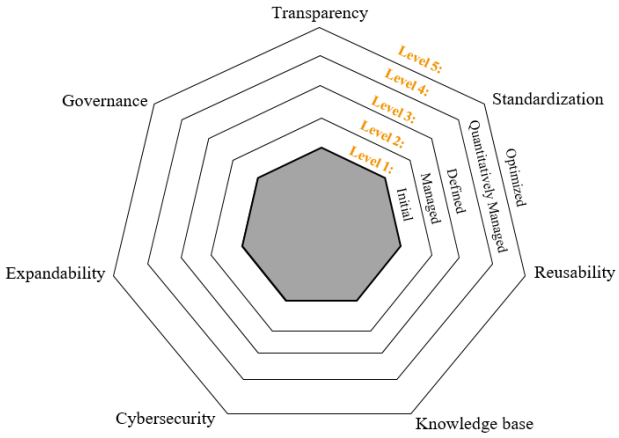

Figure 3: The DBE Maturity Model

In the following, we explain the defined DBE maturity model in more detail. We present the model in the following structure. First, we outline a definition of the maturity dimension, followed by a description and its provenance. In a second step, we illustrate a brief description of the defined maturity levels. Please note that a detailed explanation of how to precisely determine each level with its distinguishing criteria by asking determination questions is given in appendix A.5.

Transparency: *We define transparency as the opportunity for stakeholders to see the actions performed within the DBE.* This opportunity is given if every involved enterprise has clarity on the dependencies of their business processes, business models, and partner-enterprises strategy. Moreover, this includes clarity on the value-creation and the profitability of specific services and products of the DBE.

We derived this dimension since the participants (P8, P10, P12) named overcoming the challenge of untransparent linked dependencies as crucial for DBE success. Also, related maturity models [Jansen, 20, Donker and van Loenen, 17] considered transparency as a value-adding maturity characteristic implicitly within their proprietary dimensions (e.g., dimension technology). Besides, the participants (P8, P11) outlined transparency that comprises a particular overarching business process as an essential DBE maturity characteristic.

Maturity Levels:

- (Level 1) The initial level describes a DBE where enterprises have only haphazard transparency.
- (Level 2) Enterprises receive transparency only on certain parts of a DBE, which are required for the next tactical implementation steps.
- (Level 3) The transparency within the DBE is coordinated.
- (Level 4) Oversight on the operational parts of the DBE is established.
- (Level 5) Transparency on the different strategical parts of the DBE is given.

Governance: *We define governance as the process of guiding a DBE through guidelines, alignments, and decision-making.* This process steers the DBE centrally by organizing improvement initiatives, aligns the enterprise business vision, strategies, and goals to each other, and gives consultancy in setting up the right incentives and KPI's to foster DBE success. Moreover, it manages topics such as general decisions on

business continuity, on project management frameworks (e.g., agile methodologies) and monitors its execution.
We establish this analysis dimension since the participants (P5, P11, P12, P16, P19, P20, P21, P22, P24, P25, P26, P27) highlighted the governance process as crucial within DBEs, and multiple related maturity models [Saputra et al., 19, Gollhardt et al., 20, Rafael et al., 20, Jansen, 20, Cukier and Kon, 18, De Carolis et al., 17, Adrodegari and Saccani, 20, Cukier et al., 20, Mohamed, 20, Cancian et al., 20, Wagire et al., 20, Lin et al., 20, Donker and van Loenen, 17] emphasized it as an essential characteristic.
Maturity Levels:

- (Level 1) The governance functionality is on an inconsistent level.
- (Level 2) Governance functionality is mainly managing people.
- (Level 3) The governance functionality is managing competencies within the DBE.
- (Level 4) Governance functionality is managing DBE capabilities.
- (Level 5) Governance functionality is managing DBE changes.

Expandability: *We define expandability as the prerequisite of adding new technical or functional components to the DBE.* This prerequisite is given when the DBE can add new partner-enterprises and can dock to other existing DBEs. Furthermore, the DBE needs to be able to integrate new and legacy systems along with its interfaces.
We establish this dimension since the participants (P2, P3, P5, P7, P8, P11, P14, P16, P19, P21, P23, P25) outlined it as one of the main maturity characteristics. Also, related maturity models [Cukier and Kon, 18, Kreiling and Bounfour, 19, Azevedo, 19] described it as a significant maturity characteristic. Moreover, we concluded from the given DBE challenges such as the alignments for extensions (P6), the limitation of entrepreneurial freedom (P12), and the legacy system compatibility (P11, P18, P20, P23, P24, P28) as being worthy of being established within its own dimension.
Maturity Levels:

- (Level 1) The conduction of DBE extensions is reactive and unpredictable.
- (Level 2) DBE extensions are managed on a project level.
- (Level 3) Extensions are conducted proactively rather than reactively.
- (Level 4) Extensions are measured and controlled.
- (Level 5) Extensions are stable and flexible.

Cybersecurity: *We define cybersecurity as the capability of protecting a DBE's IT infrastructure and data from damage, theft, or misuse.* This capability conducts security assessments, vulnerability analysis, and compliance assessments such as GDPR (General Data Protection Regulation) compliance. In doing so, it aims to protect a DBEs property by technological or educative measures.
The topic of information security was named by many participants (P2, P23, P24, P25, P27, P28) as a major maturity characteristic of DBEs. Also, other researchers [Gollhardt et al., 20, Jansen, 20, De Carolis et al., 17, Cancian et al., 20, Wagire et al., 20] of the related assessment approaches recognized cybersecurity as a decisive issue. Moreover, we concluded from the participant's statements (P2, P3, P7, P10, P18, P19, P22, P25, P26, P27), which reveal information security and compliance as a challenge within DBEs, to be relevant as a dedicated maturity dimension.
Maturity Levels:

- (Level 1) Despite existing issues, no security and data privacy controls exist.
- (Level 2) Some security and data privacy controls are in development with limited documentation.

- (Level 3) More security and data privacy controls are documented and developed to avoid issues.
- (Level 4) Security and data privacy controls are monitored and measured.
- (Level 5) Security and data privacy controls are comprehensively implemented and automated.

Knowledge base: *We define a knowledge base as a technology allowing the storage of textual and visual information representing gained knowledge through working with a DBE.* This technology enables the participating enterprises to continually learn DBE processes, capabilities, and dependencies with the evolving DBE. Moreover, it includes a central directory of existing systems and interfaces and the planned target landscape. We establish this dimension since the participants (P2, P11, P16, P19, P21, P22) named a knowledge base as a vital maturity characteristic of DBEs, and four related maturity models [Jansen, 20, Cukier and Kon, 18, Kreiling and Bounfour, 19, Azevedo, 19] considered it as relevant. Moreover, the outlined challenges of missing know-how (P1, P15, P26) due to the complexity of DBEs (P6, P8, P9, P19) let us conclude that a knowledge base is decisive for a DBE's maturity.

Maturity Levels:

- (Level 1) The DBE knowledge base is undefined.
- (Level 2) The DBE knowledge base is established but maintained only in a basic form.
- (Level 3) The knowledge base achieves a level of expertise and is used for decision-making.
- (Level 4) The knowledge base is used for quantitative decision-making.
- (Level 5) The knowledge base is used as a sharing platform and allows for reliable decision-making.

Reusability: *We define reusability as the use of existing technical or functional components for different purposes.* This use is enabled by the opportunity to reuse existing services, platforms, solutions, use cases, and partner-enterprises for different business purposes. Moreover, it includes the reproduction of existing capabilities with new characteristics and features.

We establish this dimension since the participants (P2, P12, P13, P15, P16, P23, P24, P25) see the ability to reuse as a significant maturity characteristic. In addition, different related assessment approaches [Jansen, 20, Cancian et al., 20, Donker and van Loenen, 17] emphasized the importance of reusability. Moreover, we conclude from the named challenges (P5, P8, P9, P11, P12, P16, P22, P25, P26) of hindered reusability, that it is worth being represented within an own dimension.

Maturity Levels:

- (Level 1) Reuse is only possible in exceptional cases.
- (Level 2) Reuse is encouraged.
- (Level 3) Reuse is incentivized and rewarded.
- (Level 4) Reuse is indoctrinated.
- (Level 5) Reuse is perceived as the way the DBE is doing business.

Standardization: *We define standardization as the process of unification based on the consensus of DBE stakeholders.* This process determines standards for technological aspects, such as the information exchange via interfaces and business aspects such as a unification of DBE business processes (e.g., customer complaint management process).

We designed this dimension since many participants highlighted the degree of standardization (P2, P5, P11, P13, P15, P20, P21, P25, P26, P27) as a decisive maturity characteristic. Also, related maturity models [Jansen, 20, Adrodegari and Saccani, 20, Mohamed, 20, Cancian et al., 20] recognized the significance of standardization in their assessments. Moreover, we concluded from the challenge of missing standards (P1, P3, P5, P20, P21, P27) that it is a required maturity dimension.

Maturity Levels:

- (Level 1) The standardization is at an early stage since the enterprises use their proprietary built solutions.
- (Level 2) Standardization is building common foundations.
- (Level 3) Standardization is beginning to blueprint future solutions jointly.
- (Level 4) A standardization comprises implementing jointly designed blueprints.
- (Level 5) Standardization is rolling out predefined templates.

We propose that different employees of an enterprise should conduct the maturity assessment. First, each enterprise determines the average value and discusses potential contrasts in the assessment of their employees. Second, the participating enterprises compare their assessment and discuss potential gaps or mismatches in their maturity perception.

4.4 Application of the Maturity Model

To evaluate the usefulness of the maturity model, we applied the maturity model to DBEs from multiple industry sectors. We did this by carrying out the online survey (section 3.3). From the application results, we designed a heat map with the high-end values in yellow and the low-end values in blue. Appendix A.4 depicts these results. Our results show that the maturity model is applicable to multiple industry sectors. The application is conducted as a self-assessment, without the need for any assistance through an online survey and requires minimal effort to complete. On average, it takes 10.9 minutes to complete. The online survey calculates and shows immediate maturity feedback to the users. This feedback includes maturity points concerning each maturity dimension and the total value. It is visible that there are advanced industry sectors such as transformation consulting, defense & security, and government & public service. We can perceive industry sectors such as education, insurance, and media & entertainment on the lower end. Exceptionally, DBEs of the industry sector software & services can be very mature and less mature. This exception may indicate that the correlation between the industry sector and DBEs maturity does not appear very strong. Moreover, we calculated the standard deviation per maturity dimension from the results. Interestingly, the deviation concerning knowledge base, cybersecurity, and standardization is remarkable. This deviation may indicate different general settings within the DBEs. We ranked the maturity dimensions according to their assessment values. This procedure revealed that cybersecurity is perceived as the most mature (Rank 1) and expandability as the one with the lowest maturity (Rank 7).

4.5 Evaluation of the Maturity Model

This section shows our maturity model's evaluation results. Section 4.5.1 explains the participant's feedback from the model's application, and 4.5.2 the results of the classification taxonomy deployment.

4.5.1 Participant Feedback

We addressed feedback questions to evaluate our maturity model. In the following, we synthesize all given answers in the online survey (Appendix A.5). In doing so, we reference the discussed survey questions with the IDs FB1 – FB7.

Initially, we asked **whether the model enables comparing and assessing the maturity of existing DBEs (FB1)**. Participant (ID88) explained that the maturity model with its online assessment capability provides a framework that enables accurate maturity assessments. It was highlighted that the model is designed in a way that is applicable to different kinds of enterprises, which allows them (the participant's enterprise) to make comparisons. Moreover, the participant (ID92) explained that it is important to have a maturity model based on s.m.a.r.t. (specific, measurable, attainable, realizable, and time-bounded as well as traceable) [Mannion and Keepence, 95] formulated questions for his role as an enterprise architect. The participant emphasized that the used GQM questions (Appendix A.5) fully meet these requirements. Besides, ID92 made clear that, on the one hand, the model needs to provide questions at a quite concrete level but also remain on a generic level that enables deployments to different kinds of DBEs. The maturity model at hand achieved this trade-off very well since it allows assessing and comparing different kinds of DBEs. In addition, it was stated by ID92 that it is crucial to know the enterprise's competitive position within the DBE, which is knowledge provided by the model's comparison results. Also, participants (ID87, ID91, ID97, ID98, ID102) agreed that the model enables assessing and comparing the maturity of existing DBEs. In doing so, ID102 and ID98 outlined the enabled comparison as very helpful since it suggests improvements for existing DBE collaboration. Only ID97 stated uncertainty when it comes to comparing DBEs among different industry sectors. Except for ID97, no participant mentioned any doubts about the maturity model's capability.

Moreover, we questioned whether **the maturity model is applicable straightforwardly and provides the assessment result quickly (FB2)**. The participants (ID87, ID88, ID91, ID92, ID97, ID98, ID102) agreed by describing the maturity model as straightforwardly applicable combined with quick result provisioning. In addition, (ID88) emphasized the quite self-explaining nature of the maturity model application. Besides, ID92 highlighted that the application provides insights into DBE's strengths and weaknesses. Based on such insights, it is possible to derive an organization's individual goals. No participant mentioned any disagreeing statement.

We queried whether **the maturity model application help to identify areas for improvement in the collaboration within DBEs by considering multiple perspectives (FB3)**. The participants (ID87, ID88, ID91, ID92, ID97, ID98, ID102) affirmed that the insights help to identify areas for improvement and, therefore, helps DBEs to mature and improve. ID88 and ID98 stressed that the maturity model's consideration of different perspectives allows comparing the assessment results of

stakeholders from different departments, enterprises, which also identifies mismatching perceptions. Therefore, especially this multi-perspective assessment enabled by the maturity model is seen as valuable in deriving improvement measures and increasing mutual understanding.

Furthermore, we pointed out the question of whether a repeated application of the maturity model provides an understanding of how DBEs emerge and which maturity levels they surpass (FB4). The participants (ID87, ID88, ID91, ID92, ID97, ID98, ID102) agreed that a repeated maturity model application would provide an understanding of how DBEs emerge and which maturity levels they surpass. In doing so, ID88 outlined that it can be used to understand if an enterprise is going successfully towards the DBE business vision. In the beginning, the business vision is given, and with the maturity model, the progress towards achieving this vision can be measured. Besides, ID98 stated that repeated application increases the efficiency of the application and leads to a recognizable improved understanding of how a DBE emerges. ID92 emphasized it as particularly interesting when the growth of maturity gets visible over time. This capability helps to govern and to steer the DBE. With a similar meaning, ID97 described the continual maturity feedback provided by repeated assessments as key to validate whether the DBE matures or not. No single participant outlined any doubts about the value of repeated applications.

We explicitly asked the participants for **dimensions not included but relevant for maturity assessments of DBEs (FB5)**. The participant (ID77) stated that viability is a further relevant maturity dimension. ID95 mentioned value creation as missing. ID90 named agile methodologies as an additional dimension. Participant (ID92) mentioned that it would be worth creating a dimension for integration. ID103 emphasized a central directory for existing systems and interfaces as helpful additional dimensions. Moreover, Participant (ID91) named continuity as an item to consider. ID94 named execution as being worthy of creating an additional dimension. The participant ID101 outlined goals and vision to be achieved within the DBE as left out. ID102 added some kind of reproduction of existing capabilities as missing. In summary, no single additional dimension was proposed by more than one participant. Therefore, no proposed dimension qualified themselves to be considered in the maturity model design. According to our design principles (section 3.1.3), at least two participants need to state the same dimension to be considered in this design. The authors of this paper discussed each of the proposed dimensions and concluded that they are either already covered by the existing maturity dimensions or not addressing the needs of DBEs in general (e.g., agile methodologies are only relevant for the DBEs deploying agile methodologies).

We explicitly questioned **whether dimensions were added to the maturity model, which are not very helpful (FB6)**. The participant (ID97) selected the reusability and participant (ID98) the knowledge base. Both participants provided no further explanation for their selection. Except for the participants (ID97, ID98), all participants were satisfied with the dimensions included.

Finally, we asked whether **the maturity model application supported increasing the degree of DBE maturity (FB7)**. In general, the participants (ID87, ID88, ID91, ID98, ID92, ID97, ID102) confirmed that the maturity model supports increasing the degree of DBE maturity. ID88 explained this since it sets the foundation for supporting the business vision. ID92 stated that it does because it makes you aware of where you stand among your DBE participants and in a larger context in the whole DBE. ID98

and ID87 elaborated that the maturity model result is a pivotal contribution to raising the degree of DBE maturity. However, the results need to be considered by the management to derive improvement measures. In a similar direction, ID97 explained that not the model alone increases the DBE maturity, but it helps the participating organization identify opportunities to increase the individual businesses in the DBE. For instance, if the DBE lacks cybersecurity, all the participating organizations understand that they have to work on the cybersecurity chain. Also, ID102 stressed the value of the maturity model application to raise the degree of DBE maturity and emphasized that it also depends on the participants; since they must apply/implement the resulting recommendations.

4.5.2 Classification Taxonomy

To evaluate the effectiveness of the maturity model design, -definition, -application, and -evaluation, we compared our maturity model with other existing maturity assessment approaches from related fields through the adapted classification taxonomy. In section 3.2.2, we defined the adapted classification taxonomy parameters (Appendix A.10) and their values. These values are indicated with the symbols (e.g.,◔, ◑, ●). The following Appendix A.12 shows the results of the deployed adapted classification taxonomy, where we reference our maturity model with the shortcut "MM." Concerning the analysis dimensions, the results show that our maturity model considers more dimensions than the majority of the maturity models. Only a few authors designed maturity models with more than six analysis dimensions, which reveal that our maturity model assessments may be more comprehensive than others. However, comparing the sheer number of analysis dimensions only gives a limited indication of its comprehensiveness since the dimension's qualitative depth may differ. Therefore, we cross-checked our GQM approach and concluded its superiority in terms of comprehensiveness is reasonable. Regarding the definition method, we defined the model based on expert interviews and the latest scientific literature, while most publications either used expert interviews or scientific literature. The results addressing the application methods show that the majority of maturity models were applied through expert interviews. We applied our maturity model through an online survey and consider this as an approach that is more easily applicable to multiple DBEs. Finally, the method of maturity model evaluation is illustrated by the classification taxonomy results. Some authors provided no evaluation at all, while others conducted a single case study or a feature comparison. Our maturity model is evaluated by multiple case studies within 14 different industry sectors. Besides the classification taxonomy results, we discussed an evaluation of the number of maturity levels (section 4.2.3). We perceived that a few authors considered six or more maturity levels, such as [Jansen, 20, Azevedo, 19, Enkel et al., 20], and authors who considered four or fewer levels [Cukier and Kon, 18, Adrodegari and Saccani, 20, Cukier et al., 20, Mohamed, 20, Wagire et al., 20, Enkel et al., 20]. Our discussion concluded that the requirement for a maturity model accepted by practitioners must be self-explanatory with a not too excessive and not too low number of maturity levels. Therefore, our maturity model followed a five-level approach as foreseen by CMMI [Somaye et al., 17]. This approach allows a gradation, which can be easily recognized while also considering the complexity of intermediate values. In doing so, we agree with the literature [von Wangenheim et al., 10] that this five-level approach poses a reasonable trade-off

between accurate values and the self-explanatory meaning of maturity model results. Therefore, we left a sheer comparison of the number of maturity levels out from that classification taxonomy since our model considers the requirements of science and practice in contradiction to other maturity models.

5 Discussion

In the following, we structure this section according to the research questions (RQ1, RQ2, RQ3). Section 5.1 outlines the definition of the maturity model (RQ1), section 5.2 discusses the ramifications of the maturity model application (RQ2), and section 5.3 illustrates the maturity model's benefits (RQ3). Moreover, section 5.4 draws up an evaluation summary, and 5.5 ends with the study limitations.

5.1 Definition

Regarding RQ1, we determined analysis dimensions (1) and maturity levels (2). For (1), we analyzed and clustered existing analysis dimensions (section 4.2.2) from the SLR, used the mentioned challenges (section 4.1.2) and maturity characteristics (section 4.2.1) from the EI to derive dimensions matching the needs of DBEs systematically. To determine the maturity levels (2), we scrutinized the existing literature described in section 4.2.3. Moreover, we used the results of (1) and (2) to design the maturity model for DBEs, as explained in section 4.3. During our investigation, we revealed that the Industry lacks mature DBEs and that the definition of a maturity model seems to be of emerging interest for them. In detail, we testified that none of the existing maturity models comprehensively analyzes the DBE relevant dimensions. Moreover, we realized that the Industry perceives our research as warmly welcome since it struggles with increasing the maturity of its DBEs. Therefore, we designed a maturity model very precisely fitting to DBEs. We did this by a comprehensive analysis of existing maturity assessment approaches in DBE-related fields such as software ecosystems or Industry 4.0. In consideration of scientific attainments in the related fields, we further scrutinized IT practitioners' opinions from existing DBEs to design a maturity model. This maturity model comprises seven analysis dimensions and five maturity levels. We see this design as optimal in considering every relevant aspect and providing clarity at the same time. The clarity of the assessment results is crucial for guiding enterprises on their way towards DBE maturity. In summary, this design process allows us to conclude the dimensions such as transparency, governance, expandability, cybersecurity, knowledge base, reusability, and standardization are decisive for determining maturity and covering all relevant aspects of DBEs.

5.2 Application

Concerning RQ2, we designed a survey allowing a straightforward application (section 3.3) and applied it to existing DBEs from multiple industries (section 4.4). With this, we showed that the maturity model could be applied through an online survey by considering multiple IT practitioner perspectives and complex interdependencies. In defining this survey, we selected the GQM [Caldiera and Rombach, 94] approach to

ensure a maturity measurement with very high accuracy. The average application time of this survey is only 10.9 minutes. The measurement results are provided immediately after finalizing the survey since we developed a software extension into the online survey tool Limesurvey [Klieve et al., 10]. This extension calculates the maturity rating in real-time and provides them to the users at the end of the survey. This immediate feedback provisioning is of tremendous value-adding for practitioner's daily work with DBEs. Moreover, it is recognizable that practitioners perceive our maturity model's application as highly useful not only for its immediate feedback. The feedback of the users (ID87, ID88, ID92, ID97, ID98, ID102, ID103) emphasizes this fact. For example, (ID88) stated that the usage of a maturity model encourages enterprises to accept new challenges and fosters opportunities to become more competitive in the market. Since enterprises often cannot disruptively move over to a DBE concept, the maturity feedback guides them to transform their products and services gradually. It allows practitioners to monitor the current maturity level and the DBE's maturity progress with little effort. The model application considers multiple IT practitioners' perspectives on the DBE, which supports the identification of mismatching maturity perceptions and builds a mutual understanding. This mutual understanding is the foundation to improve collaboration across enterprise boundaries, which is essential within DBEs.

5.3 Benefits

In paying attention to RQ3, we designed an adapted classification taxonomy (section 4.5.2) to outline these benefits and showed that our maturity model provides benefits compared to other existing approaches in its high assessment accuracy and straightforward application. The adapted classification taxonomy evaluated the maturity model very precisely. In doing so, it showed our comprehensive definition method takes the latest scientific literature and expert opinions into account. As already highlighted, its straightforward and quick application within a DBE is seen as a crucial advantage. The online opportunity of model application offers benefits compared to other approaches. Moreover, it can be applied to multiple different industry sectors beyond most of its benchmark maturity models. The model is based on the well-established and longstanding CMMI [Somaye et al., 17] approach. CMMI summarizes the maturity rating in a compact illustration of self-explanatory five levels. Our investigations let us assume that the number of five levels constitutes an optimum trade-off between outlining a maturity assessment's complexity and an easily comprehensible rating. This easily comprehensible rating gives guidance in achieving DBE maturity, which practitioners perceive as very helpful. In addition, the maturity ratings can be easily benchmarked with other DBEs and enable practitioners to share best-practices. Through our evaluation (section 4.5.1), we can state that the model covers all relevant maturity aspects of DBEs. Moreover, the results (section 4.5.2) highlight that our maturity model provides benefits compared to other existing approaches since it considers all DBE relevant analysis dimensions and let us conclude our maturity model's accuracy and reliability outperform its benchmark.

5.4 Evaluation

A maturity model evaluation is seen as a crucial but also a complex and long-lasting topic (section 4.2.7.2). To attain a best-possible maturity model evaluation, we considered the maturity model evaluation requirements addressed by [Becker et al., 09]. Appendix A.13 depicts the summary of these requirements and the undertaken evaluation measures fulfilling them. Through the conducted evaluation measures, this study fulfills every maturity model evaluation requirement according to [Becker et al., 09].

5.5 Study Limitations

This section outlines potential limitations to our study by organizing them according to the applied research methods: the SLR, the EI, and the online survey.

Systematic Literature Review: The SLR described in section 3.2 might be limited by a (1) selection bias of papers, (2) missing papers, and (3) false analysis and classification. To overcome (1) and (2), we conducted the SLR according to the methods of Kitchenham et al. [Kitchenham et al., 09] and Wohlin [Wohlin, 14]. These methods guide in identifying relevant literature. In paying attention to (3), we developed a classification taxonomy (section 3.2.2), and each of the papers were read by two authors of this study. In the case of conflicting opinions, the authors discussed the studies until consensus was achieved.

Expert Interview: The EI (section 3.1) might bear specific limitations, such as (1) biased selection of participants, (2) language hurdles, (3) bias of the moderator, (4) biased answers of the participants, (5) off-topic discussions, (6) misleading interpretations, (7) wrong design of the maturity model, (8) limited IT perspective of the maturity model. To handle (1), we defined the selection criteria for the participants described in section 3.1.2. For (2, 3, 4, 5), we specified interview guidelines and provided a questionnaire, including a hand-out upfront to the participants. Moreover, we analyzed the interview results according to the method of [Mayring, 10] described in section 3.1.3 to overcome (6). To overcome (7), we designed the maturity model according to the methods and principles of [Tan et al., 20, Pöppelbuß and Röglinger, 11]. For (8), we encourage researchers to also focus on analyzing DBEs from a business perspective by outlining a future work proposal.

Online Survey: Limitations to the online survey described in section 3.3 include (1) biased definition of survey questions, (2) wrong analysis of the results, (3) wrong selection of participants, (4) limited evaluation of the maturity models effectiveness. To tackle (1), we designed the survey questions according to [Raju and Uma, 14]. This approach helps in defining survey questions that allow an objective measurement of maturity. For (2), we used the method of [Mayring, 10] that guides how to analyze openly formulated survey questions. Furthermore, two authors of this paper reviewed the analysis. In order to overcome (3), we defined the participant selection criteria described in section 3.3.2. Finally, to keep (4) at an acceptable level, we assured the fulfillment of all maturity model evaluation requirements addressed by [Becker et al., 09].

6 Conclusion and Outlook

Prior research [Floor, 06, Smith, 16, Hajibaba and Dolnicar, 18] has outlined that participation within DBEs may foster the business success of enterprises. However, no study had yet investigated the maturity of existing DBEs. Moreover, no researcher focused on any approach allowing the measurement of DBE's maturity from an IT perspective. In this study, we developed a maturity model based on the analysis results of 22 publications and 28 expert interviews. Moreover, we evaluated the maturity model by its application to 29 DBEs from 14 different industry sectors and by comparison with 22 other maturity models from related fields. With our introduced maturity model and the online application opportunity, practitioners can now run a detailed analysis of their DBEs. Considering multiple IT practitioners' perspectives on a DBE, which are provided by our maturity model, allows practitioners to identify points for improvement in a very detailed manner. Moreover, our maturity model considers the crucial DBE maturity dimensions such as transparency, governance, expandability, cybersecurity, knowledge base, reusability and standardization and provides exact assessment results through the usage of the GQM approach. In doing so, our maturity model fulfills the defined objectives of enabling comparisons and assessments of existing DBEs. By the first application, we already found multiple points of improvement within existing DBEs. In general, we established that existing DBEs in industry today lack maturity.

Our achievements extend existing research in DBEs, such as [Senyo et al., 19a, Jansen et al., 19, Pidun et al., 19, Senyo et al., 19b]. It reflects the practitioner's perspective on DBEs, attested as missing in research by [Senyo et al., 19a, Senyo et al., 19b]. Furthermore, our work clearly defines how to distinguish between different maturity levels of DBEs, which was mentioned as a research gap by [Senyo et al., 19b]. Moreover, it takes the desire for more theorization and the development of models mentioned by [Senyo et al., 19b] into account. It addresses open questions outlined by [Hedges and Furda, 19, Tan et al., 09], such as which maturity levels a DBE passes during its evolution. Most notably, this is the first study, to our knowledge, that designs a simple way to assess the maturity of existing DBEs. The maturity model application allows practitioners to reveal gaps in the DBE and distinctions of maturity within the participating enterprise by considering each participating enterprise's perspective and the IT practitioner's perspectives of multiple employees of each enterprise. This approach helps practitioners identify room for improvement in collaboration and helps enterprises assess and compare their current state with partner-enterprises within DBEs. Our maturity model gives guidance for further improvements and enables researchers to assess existing DBEs. Moreover, we provide compelling evidence for the long-term relevance of the phenomenon of DBEs. Therefore, future work should include follow-up research designed to investigate the introduced maturity dimensions' mutual interdependencies and influences. In doing so, we will further investigate potential interrelations between the identified maturity dimensions such as standardization which may underlie other maturity characteristics, and the perspectives of different stakeholders in the process of maturity assessments of DBEs. Moreover, future work should also include the analysis of DBE maturity from a business perspective and a long-term study to observe whether a DBE transforms itself according to the maturity model's suggestions.

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Appendix

https://doi.org/10.48323/fb82f-72358