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Dynamic Enterprise Architecture Capabilities: conceptualization and validation

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Abstract. The notion of enterprise architecture (EA) and EA-based capabilities in IS literature has emerged as an important research domain. However, the conceptualizations of EA-based capabilities remain ambiguous, largely not validated and still lack a firm base in theory. This study, therefore, aims to rigorously conceptualize EA-based capabilities grounded in theory and puts forward the notion of dynamic enterprise architecture capabilities. These capabilities highlight the core areas in which organizations should infuse EA. The purpose of this study is to develop a reliable and valid measurement scale. This scale is validated using item-sorting analyses, expert reviews and an empirical study of 299 CIOs and enterprise architects. The outcomes support the validity and reliability of the scale. The dynamic enterprise architecture capabilities scale developed in this research contributes to theory development and the EA knowledge base. The scale may be used as an assessment or benchmarking tool in practice.

Keywords: Enterprise Architecture, Enterprise Architecture Capabilities, Dynamic Enterprise Architecture Capabilities, Dynamic Capabilities View, Scale development and validation

1 Introduction

In today's dynamic business environment, there are various trends and market forces that drive the adoption of enterprise architecture (EA) within organizations. These include, e.g., growing regulatory pressure, the rising frequency and speed of business-driven and information technology (IT)-driven change opportunities, and an increased need for integration within and between business enterprises. Organizations are, therefore, adopting various forms of EA to facilitate the further integration of IT resources, assets and capabilities with business processes [1-3]. An EA can be considered a high-level representation of organizations' business processes and IT systems, their interrelationships [4]. While there is conceptual work that argues that EA allows organizations to add value across the organization [5, 6], much of the current literature still focus on EA artifacts, and their respective management [7-9]. Recently, the literature puts a greater emphasis on theory building and the EA-based capabilities that organize and deploy organization-specific resources to align strategic objectives with the particular use of technology [1, 10, 11].

Nonetheless, despite the recent growth in EA studies, substantial gaps remain in the literature. For instance, there is no conclusive evidence on how EA-based capabilities drive business transformation and deliver benefits [2, 4, 11-14]. Moreover, definitions and conceptualizations of EA-based capabilities remain ambiguous and large not validated [11, 15, 16]. Hence, despite the various scholarly contributions, the conceptualization of EA-based capabilities still lacks a firm base in theory. Following this assessment, there is a need to rigorously conceptualize EA-based capabilities grounded in theory and to develop a reliable and valid scale to measure its underlying dimensions. This study, therefore, aims to extend previous EA work and proposes a dynamic enterprise architecture capabilities scale that highlights the core areas in which organizations should infuse EA. Hence, we follow previous IT-enabled [17-19] and EA-based capability [1, 3, 20-22] scholarship that used dynamic capability-based approaches as a theoretical foundation. By doing so, this study embraces on a robust theoretical foundation that provides a rich vocabulary and empirically validated measures.

Given the above, this study addresses the following research question: *"how can a valid and reliable scale be developed to measure dynamic enterprise architecture capabilities and, thus, the core areas in which organizations should infuse EA?"*

This paper is structured as follows to answer this question. First, we briefly review the literature on dynamic and EA-based capabilities. Then, this work outlines the development process and methods. Sections four and five present the results, i.e., a validated conceptualization of dynamic enterprise architecture capabilities, the discussion of the results and the conclusions.

2 Theoretical background

2.1 EA-based Capabilities

The notion of differential organizational benefits that can be derived from EA-based capabilities has been subject of discussion in the past decade [4, 10, 11]. Recently, some researchers argue that managing and deploying an EA is, in fact, an organizational capability that can provide organizations with a competitive edge [1, 3]. In this particular context, a distinction can be made between EA capabilities and EA-based capabilities. EA capabilities include an organization's ability to create and maintain EA content, standards and guidelines. In essence, these capabilities focus on the development of EA artifacts, i.e., individual documents that describe various aspects of the EA [7, 23]. EA-based capabilities highlight the usage, deployment, and diffusion of EA in decision-making processes, and the organizational routines that drive IT and business capabilities [1, 3, 24]. Thus, these capabilities focus more on the development of unique competencies and capabilities that can leverage EA assets and resources. For instance, Shanks et al. [3] argue that EA capabilities are deemed necessary to provide advisory services to the organization. Likewise, Hazen et al. [1] provide foundational work that shows that EA-based capabilities can enhance organizational agility and indirectly enhance organizational performance. These outcomes are consistent with work by Foorthuis et al. [10] that demonstrate the importance of intermediate EA-enabled outcomes that contribute to the achievement of particular business goals and objectives.

Hence, EA literature suggests that complementary EA capabilities enable firms to leverage their EA effectively [1, 4], contribute to IT efficiency and IT flexibility [25], and can drive alignment between business and IT [26].

This study concurs with this EA-based capability view and uses it to frame a new conceptualization of dynamic enterprise architecture capabilities systematically.

2.2 Dynamic Enterprise Architecture Capabilities

As organizations are investing in their EA, not all of them are successful and fail to deliver desired results and, therefore, they question the particular added value of EA [1]. This study claims that it is likely that the extent to which EAs are leveraged successfully within the organization depends on the dynamic capabilities that collectively use the EA to sense environmental threats and business opportunities, while simultaneously implementing new strategic directions. Dynamic capabilities can be considered an organizations' ability to integrate, build, and reconfigure internal and external competences to address the rapidly changing environment or when the opportunity or need arises [27]. Based on the dynamic capabilities view and recent EA-based capabilities work [1, 3, 11], this study defines dynamic enterprise architecture capabilities as *"an organization's ability to leverage its EA for asset sharing and recomposing and renewal of organizational resources, together with guidance to proactively address the rapidly changing internal and external business environment and achieve the organization's desirable state."*

Building on previous EA-based capability contributions and theoretically guided by the dynamic capabilities view, we synthesize the reach and range of EA-based capabilities through three related, but distinct capabilities, i.e., I) EA sensing capability, II) EA mobilizing capability, and III) EA transformation capability. EA sensing capability refers to an organization's deliberate posture toward sensing and identifying new business opportunities or potential threats, and developing a greater reactive and proactive strength in the business domain using EA [3, 20]. EA mobilizing capability refers to organizations' capability to use EA to evaluate, prioritize and select potential solutions and mobilize resources in line with a potential solution or potential threats [3, 28, 29]. Finally, an EA transforming capability can be considered the ability to use the EA to successfully reconfigure business processes and the technology landscape, to engage in resource recombination and to adjust for and respond to unexpected changes [3, 17, 30, 31].

3 Construct development process and methods

3.1 Construct development and specification

This research followed a staged approach to tackle a magnitude of challenges (e.g., selection indicators, reliability, and validity of constructs) that emerge during the development of new multi-item scales [32]. First, the principal investigator derived all the items to reflect the new construct from either previously cited in or implied by extant conceptual and empirical work. Hence, this study adapted validated measures from recognized empirical studies in information systems and sciences [3, 17, 29], management,

organization, and decision sciences [18, 27, 31, 33]. Starting from the conceptualization of dynamic capabilities by [27], this study subsequently assigned measurement items to one of the three capabilities on the base of a review of primary scales present in the extant literature. The first pool of scale items was developed using a seven-point Likert-type scale, ranging from ''strongly disagree'' to ''strongly agree.'' Then, two subsequent stages of scale development and purification followed based on previously outlined recommendations [32], i.e., I) item-sorting analysis and expert review and II) confirmatory analyses to assess the psychometric properties of the dynamic enterprise architecture capabilities scale.

Stage I: item-sorting analysis and expert reviews.

First, an item-to-construct sorting approach was employed to establish tentative item reliability and validity. Three Master students[1], doing their theses research, evaluated the initial item pool using a Q-sort approach during two three-hour intensive sessions. Through this iterative approach, the students were asked to sort the items according to the three underlying capabilities of the new construct. Hence, the inter-judge agreement was measured [34]. Next, the student reworded or deleted too ambiguous items as a result of the first stage, to improve the agreement between the judges [35]. These two steps enhanced the reliability and construct validity of questionnaire items at a pre-testing stage. This study omits the results of these intensive sessions for the sake of brevity.

To further enhance the content and face validity of the questionnaire times, the principal investigator asked ten experts with the appropriate competencies, familiarity with the research domain, and experience to evaluate all the scale items and offer improvement suggestions. These experts were enterprise architects (3), EA and MIS scholars (2), IT/business consultants and managers (5). The experts mainly looked at several criteria for testing the adequacy of questions including length, specificity and simplicity, and question order. Also, the experts were asked to reflect on any interpretation issues with the questions [36]. Outcomes of this stage offered many small iterations, improvements, and purifications to the questionnaire items and so formed a solid foundation for the final stage to assess the psychometric properties of the new scale. Table 1 shows the final items and the supporting literature for all the three capabilities.

Stage II: survey analyses.

This study applied confirmatory analyses to the dynamic enterprise architecture capabilities construct to assess the reliability and validity of the multi-item scales [32]. The conceptualization of dynamic enterprise architecture capabilities uses a formative higher-order construct that is composed of three underlying first-order dimensions [37]. As such, this second-order factor uses reflective first-order latent constructs. The manifest variables are, therefore, affected by the latent variables and are interchangeable [38, 39]. Thus, on the first-order level, the manifest variables reflect and depict the

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[1] These students also governed the data collection process throughout this study.

construct. The second-order factor (dynamic enterprise architecture capabilities), on the other hand, is conceptualized through a formative mode. Such a model is called a reflective-formative type II model [40, 41]. Each of the three specified dimensions represents a unique trait of the higher-order construct. Removing a particular dimension would substantially alter the meaning and understanding of the overarching construct.

Table 1. Final measurement items for Dynamic Enterprise Architecture Capabilities

Constructs and items	Supporting literature
(I) EA sensing capability	
S1. We use our EA to identify new business opportunities or potential threats.	[3, 17, 18]
S2. We review our EA services regularly to ensure that they are in line with key stakeholders wishes.	[3, 17, 18]
S3. We adequately evaluate the effect of changes in the baseline and target EA on the organization.	[3, 18]
S4. We devote sufficient time enhancing our EA to improve business processes.	[17, 18]
S5. We develop greater reactive and proactive strength in the business domain using our EA.	[17, 18, 28]
(II) EA mobilizing capability	
M1. We use our EA to draft potential solutions when we sense business opportunities or potential threats	[3, 28, 29]
M2. We use our EA to evaluate, prioritize and select potential solutions when we sense business opportunities or potential threats	[3, 28, 29]
M3. We use our EA to mobilize resources in line with a potential solution when we sense business opportunities or potential threats	[17, 42]
M4. We use our EA to draw up a detailed plan to carry out a potential solution when we sense business opportunities or potential threats	[28, 29]
M5. We use our EA to review and update our practices in line with renowned business and IT best practices when we sense business opportunities or potential threats	[33]
(III) EA transforming capability	
T1. Our EA enables us to successfully reconfigure business processes and the technology landscape to come up with new or more productive assets	[3, 17, 30, 31]
T2. We successfully use our EA to adjust our business processes and the technology landscape in response to competitive strategic moves or market opportunities	[3, 17, 43, 44]
T3. We successfully use our EA to engage in resource recombination to better match our product-market areas and our assets	[18]
T4. Our EA enables flexible adaptation of human resources, processes, or the technology landscape that leads to competitive advantage	[45]
T5. We successfully use our EA to create new or substantially changed ways of achieving our targets and objectives	[45]
T6. Our EA facilitates us to adjust for and respond to unexpected changes	[17, 27, 46]

3.2 Data collection procedure

This study collected data as part of a Master course Enterprise Architecture of a Dutch University. Students[2] read recent academic articles on EA competences and capabilities, e.g., [1, 3, 4], and had to fill in a survey for their organization. Also, the participating students (N=235) had to distribute this survey to two domain experts (professionals that are familiar with the material, e.g., CIOs, IT managers, and lead enterprise architects) following a snowball method. Thus, this research collected the data through respondent-driven sampling. Following [47] there is no reason to presume that the use of the respondent-driven sampling method resulted in an unacceptable (self-reported) bias that would jeopardize the outcomes of this research.

During the data collection, controls were built in, so that every organization completed the survey only once. Respondents were given an incentive to take part in the survey. They were offered a research report with the most important outcomes of this study. Following Podsakoff et al. [48] anonymity was guaranteed, and respondents could withdraw their scores if they wanted to.

The data collection phase started on the 17th of October 2018 and ended on the 16th of November 2018. In total 669 respondents from different organizations initially started the survey. Based on the final response, this study included a total of 299 usable questionnaires for the analyses. The majority of respondents operate in the private sector 57%, 36% from the public sector and only a small percentage (0.07) from other categories such as private-public partnerships (0.02%), and non-governmental organizations. The majority of responses were from large organizations with 3000+ employees (45%), 1001–3000 employees (14%), 301–1000 employees (13%), 101–300 employees (11%) and the remaining 16% had less than 1000 employees. 69% of the organizations are older than 25 years. Sub-group analyses for each dimension of the construct (using t-tests) showed no significant difference early (first two weeks) and later responses (final two weeks) to the survey. The data were obtained from a single source at one point in time. This study, therefore, controlled for common method variance (CMV) per suggestions of Podsakoff [48]. In doing so, Harman's single factor test was performed using IBM SPSS Statistics™ v24 on the primary study constructs. Hence, the construct variables were all loaded on to a single construct in an Exploratory Factor Analysis (EFA). Outcomes of this analysis showed that no single factor attributes to the majority of the variance; the sample is not affected by CMB [48].

4 Model estimation and validation

4.1 Model estimation procedure

For the model estimation, the present study ran parameter estimates for the measurement model. The analyses were done using SmartPLS version 3.2.7. [49], which is a Structural Equation Modeling (SEM) application using Partial Least Squares (PLS). This study uses PLS for theory development purposes and to validate the measurement

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[2] Students that take part in this course are adults that have many years of working experience in either business or IT (management) functions.

model and examine the formative nature of our second-order factor model [41, 50, 51]. In the analyses, the factor weighing scheme within SmartPLS was applied. Also, a non-parametric bootstrapping procedure was employed to compute the level of the significance of the regression coefficients running from the first-order constructs to the second-order construct. In this process, 5000 replications were used to obtain stable results and to interpret their significance. Finally, the 299 organizations in the dataset far exceed all minimum requirements to run the SEM analyses [52, 53].
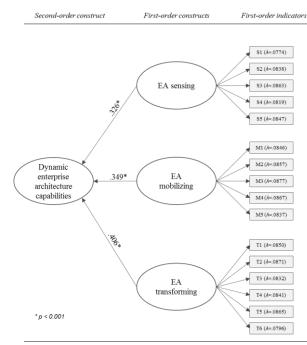

Fig. 1. Formative dynamic enterprise architecture capabilities measurement model

4.2 Confirmatory analyses

The first-order constructs were subjected to internal consistency reliability, convergent validity, and discriminant validity tests to assess the psychometric properties following the suggestions of Ringle et al. (2012), [49] and MacKenzie et al. (2011). Hence, all Cronbach Alpha (CA) values were examined if they were above the threshold of 0.70 [53, 54]. Next, the measurement model is evaluated by its convergent and discriminant validity [50, 53]. The composite reliability (CR) values for each construct should typically between 0.60 and 0.90, as is the case in the present study (see Table 2). Also, the construct-to-item loadings were assessed, showing no violations. The average variance extracted (AVE) values were all above the lower limit of 0.50 [53, 55]. Discriminant validity was established through three different, but related tests. First, analyses showed that all cross-loadings (i.e., correlation) on other constructs were less than the outer loading on the associated construct [56]. Second, analyses showed that the square root of the AVEs, i.e., the Fornell-Larcker criterion, of all constructs was larger than the

cross-correlation [50]. Third, and finally, a newly developed discriminant validity analysis was employed, i.e., the heterotrait-monotrait (HTMT) ratio of correlations approach by Henseler, Ringle, & Sarstedt [57]. All HTMT values showed acceptable outcomes well below the 0.90 upper bound. Table 2 shows the summary of the measurement model analyses that suggest that the first-order constructs are valid and reliable. As can be seen from Table 2, the included variance inflation factors (VIFs) values are well below a reported critical value of 5. These outcomes, in addition to the absence of non-significant relations between first-order capabilities and the second-order construct, indicate that no multicollinearity exists within our model [58].

Table 2. Assessment of convergent and discriminant validity of the reflective constructs.

	CA	CR	AVE	VIF	(1)	(2)	(3)
(1) EA sensing	0.885	0.916	0.686	3.209	**0.826**		
(2) EA mobilizing	0.909	0.932	0.734	3.163	0.782	**0.857**	
(3) EA transforming	0.918	0.936	0.711	3.193	0.784	0.780	**0.843**

The above outcomes confirm the three related, but unique EA capabilities that underly the formation of an organization's dynamic enterprise architecture capabilities. Figure 1 shows the respective significant path weights of the first-order constructs on the higher-order construct along with the construct-to-item loadings.

5 Discussion and conclusion

5.1 Theoretical and managerial implications

This paper contributes to the extant literature on EA capabilities by constructing and validating a comprehensive capability and treating it as a dynamic capability. Second, by developing 16 measurement items across three dimensions, this study helps researchers conduct more systematic analyses on the organization's EA-based capabilities. Hence, this work enhances the theoretical underpinnings of empirical EA and dynamic capability research. Third, the dynamic enterprise architecture capabilities scale can guide IS scholars and practitioners in explaining IS-related phenomena. Specifically, it is well understood in the literature that EA-induced capabilities—following IT-enabled capabilities [59]—have an indirect effect on organizational benefits and competitive performance, by strengthening and renewing organizations' operational (ordinary) capabilities. Therefore, scholars can investigate how dynamic enterprise architecture capabilities influence organizational benefits following these theoretical suggestions. Also, the conception of dynamic enterprise architecture capabilities can also work as a mediating construct in a nomological value path in explaining how, e.g., EA resources, assets, and practices lead to enhanced business value (e.g., business-IT-alignment, innovation). Finally, research could conceive dynamic enterprise architecture capabilities as an outcome construct by studying its antecedents like EA competencies and approaches, principles that guide the design and evolution of EA, and architectural insights.

The dynamic enterprise architecture capabilities scale is a reliable and valid tool to measure the level of proficiency of the organization's deployment and usage of EA in the organization. IT and business managers can drive enterprise-wide transformational changes and provide an opportunity to build capabilities in parallel with implementing a new strategic direction using this scale. In doing so, they can use this scale for evaluation purposes. For instance, the scale can be used in a critical self-assessment of the organizations' EA strategy to unfold development opportunities, possible even within different departments, and layers within the organization. The scale encourages decision-makers to actively think about EA deployment in the organization and how they should allocate resources properly. Hence, they can look at dynamic enterprise architecture capabilities as a means to drive the organization's level of innovation and purposefully enhance its evolutionary fitness. Finally, the dynamic enterprise architecture capabilities scale provides a useful diagnostic and benchmarking tool with which they can assess and continuously monitor their organization's development needs and compare the results with other organizations that, e.g., operate in the same industry, market or segment.

5.2   Limitations and concluding remarks

This study has several limitations. A key limitation of this study is that all the data were gathered from Dutch-speaking organizations. So, comparing measurement scores across countries might well contribute to the generalizability of our findings. Second, the data included various demographic variables (e.g., type, size), but the present study did not consider possible differences among group segments and clusters. Notwithstanding, this study advances our understanding of EA-based capabilities by developing a reliable and valid scale that highlights the core areas in which EA should be infused to create value. Both scholars and practitioners can use the scale.

Acknowledgment

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