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Gong, Yiwei; Janssen, Marijn

DOI
10.1007/s10796-022-10298-x

Publication date
2022

Document Version
Final published version

Published in
Information Systems Frontiers

Information Systems Frontiers
https://doi.org/10.1007/s10796-022-10298-x

Why Organizations Fail in Implementing Enterprise Architecture Initiatives?

Yiwei Gong[1] · **Marijn Janssen**[2]

Accepted: 24 May 2022

Abstract
Enterprise architecture (EA) initiatives consist of functions, processes, tools, instruments, and principles to guide the design of IT and its alignment with business. EA is often presented as a silver bullet to ensure that IT contributes to business. Yet, many EA initiatives do not work out or even fail, but in the literature this area is undertheorized. This study aims to understand the factors influencing the failure of EA initiatives. We identified 15 factors and invited 8 EA experts to evaluate the factors and their influence based on an approach combining grey systems theory, Decision-Making and Trial Evaluation Laboratory (DEMATEL), and Interpretative Structural Modeling (ISM). The findings indicate that the factors are correlated and interwoven in complex causal chains. This study reveals the root factor and suggests enhancing high-level managers' EA knowledge and ensuring communication and leadership skills of enterprise architects as the starting point to avoid EA failure. Only later, organizing the EA function becomes important.

Keywords Enterprise Architecture · IT architecture · IT failure · DEMATEL · ISM · Grey systems theory

1 Introduction

Enterprise Architecture (EA) has been widely used in industry and government to manage their complex IT-landscape, as a continuously changing process for organizations (Foorthuis et al., 2016; Tamm et al., 2011). EA initiatives typically consist of functions, processes, tools, instruments, and principles to guide the design of ICT and its alignment with business to meet the organization's objective (Boh & Yellin, 2006). EA initiatives are often conducted by one or more architects, using architectural tools and instruments, given certain authorities and responsibilities in the organization. Strategic planning based on EA can bring various benefits to organizations, including agility (Anthony Jnr, 2021), interoperability (Niemi & Pekkola, 2019), facilitate decision-making in IT investments (Jonkers et al., 2006), IT cost-saving (Kappelman & Zachman, 2013), and so on.

Although many benefits are accounted for by EA, these benefits are difficult to measure in practice (Schmidt & Buxmann, 2011). Many business operations managers do not see the value returned from their EA investments (Kaisler & Armour, 2017). Consultancy reports have indicated that two-third of EA initiatives failed in the past (Roeleven, 2010), and about 40% of EA programs were shut down within three years (Sessions, 2009). EA scholars also indicate that many organizations are either unable to implement their EA plans or only able to implement a part of their plans (e.g., Al-Kharusi et al., 2021; Hope et al., 2017). In some circles, EA is blamed for being over-budget, over-time and costly without the expected return on investment (Gerber et al., 2020). The high risk and failure rate impede the adoption and implementation of EA, further making the adoption of novel digital technologies, such as big data analytic, in isolation and resulting in difficulties in integration (Arjun et al., 2021; Gong & Janssen, 2021). In this sense, theorizing and understanding the reasons and causes of EA failure is indispensable knowledge to make EA implementation effective, especially for the practitioners and organizations with limited EA experience.

✉ Yiwei Gong
yiweigong@whu.edu.cn

Marijn Janssen
M.F.W.H.A.Janssen@tudelft.nl

1 School of Information Management, Wuhan University, 430072 Wuhan, China

2 Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands

Published online: 09 June 2022

Much research is contributing to achieving the benefits of EA, but scant attention is given to EA failure (Kotusev, 2017). EA practice encounters many challenges and difficulties, such as complexity (Iyamu, 2019), stakeholder engagement (Kurnia et al., 2021), communication (Banaeianjahromi & Smolander, 2019), modelling (Pérez-Castillo et al., 2020), and proper use of EA artifacts (Niemi & Pekkola, 2017). Although these studies provide implications to practitioners in addressing EA challenges, the knowledge is in fragments, reflecting a fundamental problem of lacking explanatory theory in the field of EA (Tamm et al., 2011). Previous research reveals that factors influencing EA failure are not in isolation, but have interwoven cause-effect relationships with different levels of influence (Gong & Janssen, 2020). We argue that EA failure is undertheorized and, to address this knowledge gap, we need to fundamentally and empirically revisit the causes of EA failure and to understand the interdependencies among the causes. Therefore, it is essential to provide a comprehensive model for identifying, clustering, and analyzing the factors. Based on the interrelationships among the factors, this study explores the reason for EA initiatives' failure to better plan the EA initiatives by considering causal relationships between the identified factors and their more appropriate understanding.

In this study, we employed the Decision-Making and Trial Evaluation Laboratory (DEMATEL) and Interpretative Structural Modeling (ISM) method in combination with grey systems theory (Deng, 1982) to analyze inputs from EA experts. The findings provide practitioners and researchers with the identified factors determining the failure or success of EA implementation, provide insights into improving EA practice, and result in several further research recommendations.

The paper is structured as follows. We discuss concepts of DEMATEL, ISM, and grey systems theory and literature review of EA failure factors in Sect. 2. Thereafter, the research approach is explained in Sect. 3. In Sect. 4, we present research findings of EA failure factors in practice. Practical and theoretical implications, limitations, and future research are discussed in Sect. 5, followed by the conclusion in Sect. 6.

2 EA Failure Factors from the Literature

We employed the Web of Science (WoS) search engine to identify EA failure factors to find high-quality journal articles in its SCIE and SSCI indexes and create a literature database. We used "Enterprise Architecture" as a term to search in the "Topic Field" which included title, abstract, author keywords and Keywords Plus. The WoS search engine provides an additional keywords summary called KeyWords Plus to include more keywords that are index terms created from significant, frequently occurring words in the titles of references cited in the articles. Bibliometric analyses of the structure of scientific fields should use Keywords Plus because it enables the discovery of articles that may not have appeared in the search due to changes in scientific keywords over time (Zhang et al., 2015). For example, some early publications might not have used the term "Enterprise Architecture" but instead referred to the 'IT architecture' in their abstract and author keyword list. The use of KeyWords Plus can minimize the impact of keyword changes on the search of the literature. The search for articles in the last 15 years results in a database of 325 articles of available EA publications from 2006 to April 2021. By searching the terms of "fail" or "failure", "challenge" and "risk", we arrived at a subset of 32 articles. We further analyzed these articles to learn about the knowledge of EA failure factors. The factors abstracted from EA literature were evaluated by a small group of five senior EA experts. Identifying and formulating the factors was an iterative process with two rounds of expert reviews and an academic conference discussion in between (Gong & Janssen, 2020). Furthermore, to avoid the same experts dominating the result, these five EA experts were not involved in the later data collection for the DEMATEL analysis.

In literature, there are only a few articles about the failure of EA. Table 1 summarizes the factors of EA failures from the literature. EA initiatives require a wide spectrum of skills and capabilities of enterprise architects, including modeling and planning by EA tools as well as communicating with various stakeholders during EA development. However, it is often difficult for organizations to judge if their architects match the needs of capabilities in their EA initiatives (Walrad et al., 2014). Furthermore, enterprise architects' roles are often unclear, resulting in confusion regarding their involvement in projects (Gellweiler, 2020). EA initiatives need enterprise architects and stakeholders are both capable. The unavailability or inability of stakeholders has been frequently mentioned as an EA-related problem areas (Kurnia et al., 2021). A typical challenge is the limited capability and readiness of stakeholders to precisely define their requirements and application scenarios (Brandis et al., 2014). Furthermore, poor motivation and insufficient understanding of EA by stakeholders could result in ineffective interactions with them during EA development (Votto et al., 2021). According to Banaeianjahromi and Smolander (2019), lack of communication and collaboration refers to a cause type influencing the failure of EA efforts. Specifically, it refers to the lack of knowledge and support inside organizations. In practice, enterprise architects are required to liaise with business and technology stakeholders. If the architects are not able to bridge the gap between themselves and their stakeholders, it will be hard to obtain support for and commitment to the implementation of EA (Dale & Scheepers, 2020).

Table 1 EA failure factors from literature

Label	Description EA failure factor	Representative references
F1	Unclear roles and quality of enterprise architects	(Gellweiler, 2020; Walrad et al., 2014)
F2	Inability and lack of readiness for stakeholders	(Brandis et al., 2014)
F3	Insufficient architecting, communication, and leadership skills of enterprise architects	(Al-Kharusi et al., 2021; Banaeianjahromi & Smolander, 2019; Dale & Scheepers, 2020)
F4	Lack of motivation and acceptance among IT personnel	(Banaeianjahromi & Smolander, 2019; Löhe & Legner, 2014)
F5	Business silos and conflicting interests of stakeholders	(Kurnia et al., 2021; Wood et al., 2013)
F6	Lack of EA knowledge for high-level managers to make use of EA	(Banaeianjahromi & Smolander, 2019)
F7	Lack of support from the management	(Banaeianjahromi & Smolander, 2019; Löhe & Legner, 2014)
F8	Too much effort for developing the initial EA documentation and further maintenance	(Löhe & Legner, 2014)
F9	Existing EA artifacts unused in daily work	(Löhe & Legner, 2014)
F10	EA function is isolated from IT governance processes	(Aier, 2014)
F11	Lack of accurate and smart modeling tools	(Safari et al., 2016)
F12	Lack of clear methodologies for EA implementation projects	(Nam et al., 2016; Safari et al., 2016)
F13	The high complexity of organizations, their IT landscapes, and institutional context	(Ajer et al., 2021; Kurnia et al., 2021)
F14	Organizational politics and conflicts	(Ajer et al., 2021; Kurnia et al., 2021)
F15	Too dynamic environment	(Kurnia et al., 2021)

The source of power arrangement in an organization and the role and responsibilities of employees also influence the development of EA (Kar et al., 2021). The diversity of stakeholders with different roles and responsibilities in a large organization often presents a complex interrelation among them with multiple attitudes and conflicting interests to be addressed in EA development. Wood et al. (2013) indicate that solely focusing on stakeholders via isolated viewpoints will fail to capture the stakeholders as a system. This makes them hard to be involved and reach agreements on architectural questions and solutions (Kurnia et al., 2021). Such a situation could be even worse if high-level management does not understand the benefit of EA and provide sufficient support and commitment to it (Banaeianjahromi & Smolander, 2019).

EA is often regarded as a separate and parallel initiative, although it needs to be embedded in the established management processes. This often results in coordination problems requiring additional adjustments effort, which in turn decreased the EA initiatives' acceptance (Löhe & Legner, 2014). For example, a lack of coordination between the EA initiative and a parallel ITIL initiative created contradictory perceptions and redundant documentation. EA artifacts, such as models and principles, are intended to be used to enable an organization's events, processes, and activities. But when they become complex, they can constrain the same activities meant to support and enable (Iyamu, 2019). Complete EA artifacts are not feasible due to the many stakeholders, the high organizational complexity, the continuous change, and the large scope. Even worse, organizations often do not update EA documents continuously. EA repositories gradually become outdated and are perceived as being of low quality. The poor quality of EA artifacts can result in a lack of use in daily work and decision-making (Löhe & Legner, 2014).

There are also factors in the aspect of technology about insufficient support for the interactions between EA architects and artifacts, such as the lack of accurate and smart modeling tools and lack of clear methodologies for EA implementation, are often considered as risks rather than the reasons of failures (Safari et al., 2016). According to Hope et al. (2017), these factors were found to reflect the technical sophistication of EA tools rather than that they determine EA success. In their case studies, they found EA failures were more likely caused by communication and commitment problems. In contrast, Nam et al. (2016) argued that EA methodology applied to a single organization tends to fail when EA is applied at the national level by the central government to aggregate diverse agencies and organizations.

The environmental factor refers to social resources, norms, policy, rules, standards, and organizational context. Recent EA studies indicate that some prior EA studies often focus on interpersonal interactions and dynamics but ignore the influence of institutional complexity (Ajer et al., 2021). The complexity of EA initiatives is often rooted in the overall complexity of the organization and its IT landscape. Conflicting interests of stakeholders add not only to this complexity, but also the politics and institutional logics in government or conglomerate context that may lead to a disassociation from EA visions (Ajer et al., 2021). Furthermore, environmental volatility could result in turbulence and whimsicality of the organizational environment, reduce the value of planning exercises, and discourage stakeholders from participating in EA development (Kurnia et al., 2021).

There are limited studies in literature focusing on the failures of EA implementation. Often, various factors influencing EA implementation are discussed as challenges (e.g., Löhe & Legner 2014), risks (e.g., Safari et al., 2016) or inhibitors (Kurnia et al., 2021). Some factors might even be arguable on their validity (Hope et al., 2017). Although a few studies also include a literature review and provide useful input and taxonomy for understanding these factors (e.g., Kotusev 2017; Kurnia et al., 2021), they are either ignoring or not able to identify the interrelationships between factors, and consequently, they do not reveal the importance of different factors. This motivates our study on clarifying these 16 factors of EA failures and their complex interrelationships. The findings and discussion should help enterprise architects to ensure the survival of their EA initiatives by understanding and tackling the root cause of failure.

3 Research Approach

3.1 Combining DEMATEL, ISM and Grey Systems Theory

Theoretically, EA is a very complex system that incorporates a set of interdependent elements. As a result, a model that is able to account for these complex relationships needed to be selected for analysis. DEMATEL and ISM methods appear to be suitable algorithms for providing a clear display of the interactive relationships within the system (Wang et al., 2018). Both DEMATEL and ISM methods have proved to be powerful techniques to capture the complex relationships in a system. A hybrid DEMATEL and ISM approach have proved to be a robust approach to study cause-effect relationships on account of similarities between them and have found numerous applications in previous research (Trivedi et al., 2021).

DEMATEL is a mathematical method widely used to analyze complex management problems (Tzeng et al., 2007). This method analyzes the interaction among the factors by categorizing them into cause or effect groups and contributing to identifying feasible solutions in a hierarchically structured manner (Wu, 2008). For example, Bai and Sarkis (2013) employed the DEMATEL approach to visualize the structure of complicated causal relationships between critical success factors and obtained the influence level of business process management factors. Xia et al. (2015) analyzed internal barriers encountered by automotive parts remanufacturers and evaluated causal barriers using a proposed model framework. The DEMATEL method can also be used to analyze the causal relationships and interactive influence among criteria (Tsai et al., 2016).

The ISM method was formulated as a mediating channel for complicated problems among the factors (Warfield, 1974). ISM helps in ranking the factors and solving complex problems in a logical flow. ISM is a reliable technique when the objective is to structure a problem and provide a systematic ranking. It assists decision-making by developing a hierarchy with which to confront such variables as challenges (Kumar & Dixit, 2018). ISM is an interactive learning process to discover whether and how a number of factors are related and portrays an overall structure and the specific relationships extracted from the complex set of factors in a directed graph model through a hierarchical configuration (Janssen et al., 2018). It has been widely used in operation and management research (e.g., Kannan & Haq 2007; Nitin Yashwant & Ravi, 2016) and recently also in the field of information systems (e.g., Dwivedi et al., 2017; Sharma et al., 2021).

As EA is used in organizations, there are many uncertainties, which can be addressed by using the Grey-DEMATEL technique. Grey theory was developed by Deng (1982). It deals with uncertain systems with partially known information through generating, excavating and extracting useful information from available but limited data to effectively describe and monitor the systems' operational behaviors and their laws of evolution (Liu et al., 2012). Grey systems theory is highly recommended for analyzing the data set that is discrete and comes from multiple inputs; and for the systems with poor and insufficient information (Hsu & Wen, 2000; Tseng, 2009). It is also highly recommended for group decision-making, and it infers results from a small set of data (Liu & Qiao, 2014).

Integration grey theory with DEMATEL method has been successfully used in, for example, finance (Jin et al., 2012), airline (Hsu & Wen, 2000), and manufacturing (Xia et al., 2015). Similarly, a hybrid DEMATEL-ISM method is also widely used in previous research. For example, Kamble et al. (2020) investigated the complex causal relationships between the blockchain enablers in the agriculture supply chain. Song et al. (2020) analyzed barriers for adopting sustainable online consumption integrating the combination of DEMATEL-ISM methods. The above examples show the compatibility of the three methods and the feasibility of combining them.

Although a combination of these three methods is hardly presented in previous research, the combined use of these three methods can complement each other. Grey theory uses grey linguistic variables to facilitate decision-making under uncertainty. DEMATEL is applied to determine the intensity of quantified relationships among EA failure factors, while ISM is used to identify the interrelationships among the factors, and also helps to prioritize and determine the level of factors in a system (Shakeri & Khalilzadeh, 2020). A hybrid grey-DEMATEL-ISM approach is employed to analyze the EA failure factors in this study. The operationalization of the hybrid approach will be explained in the methodology section.

3.2 Overview Research Approach

Our grey-DEMATEL-ISM approach for influencing factors of EA failure has the following main steps, presented in Fig. 1 (based on Bai & Sarkis 2013; Cui et al., 2019; Govindan & Chaudhuri, 2016; Kumar & Dixit, 2018; Rajesh & Ravi, 2015; Wang et al., 2018).

Step 1 Identify EA failure factors and develop direct-relation matrices. We have extracted a list of factors influencing EA failure by literature review and interaction with EA experts in previous research. This results in a set of direct-relation matrices A, (where, denotes the influence of the factor i on the factor j).

Step 2 Construct the factors of EA failure based on grey theory. There are four tasks in this step.

- Step 2a: Formulate a grey linguistic scale for experts' assessments (Table 2). We use a five-level scale from "No influence" to "Very high influence" for data collection from EA experts.
- Step 2b: Based on grey theory, calculate the grey number:

$$\otimes x_{ij}^k = \left[\otimes \underline{x}_{ij}^k, \overline{\otimes} x_{ij}^k\right] \tag{1}$$

Table 2 Linguistic scale for assigning greyscale and crisp values

Linguistic Assessment	Crisp Values	Grey Scale
No influence	0	[0,0]
Very low influence	1	[0,1]
Low influence	2	[1,2]
High influence	3	[2,3]
Very high influence	4	[3,4]

Then normalize the grey number on the lower bound by the following equations, where K is the number of experts.

$$\otimes \underline{\bar{x}}_{ij}^k = \frac{\otimes \underline{x}_{ij}^k - \min \otimes \underline{x}_{ij}^k}{\Delta_{min}^{max}} \tag{2}$$

$$\overline{\otimes} \bar{x}_{ij}^k = \frac{\overline{\otimes} x_{ij}^k - \min \overline{\otimes} x_{ij}^k}{\Delta_{min}^{max}} \tag{3}$$

$\otimes \underline{\bar{x}}_{ij}^k$ and $\overline{\otimes} \bar{x}_{ij}^k$ are the lower and upper bounds of $\otimes$, respectively, and

$$\Delta_{min}^{max} = max \overline{\otimes} x_{ij}^k - \min \otimes \underline{x}_{ij.}^k \tag{4}$$

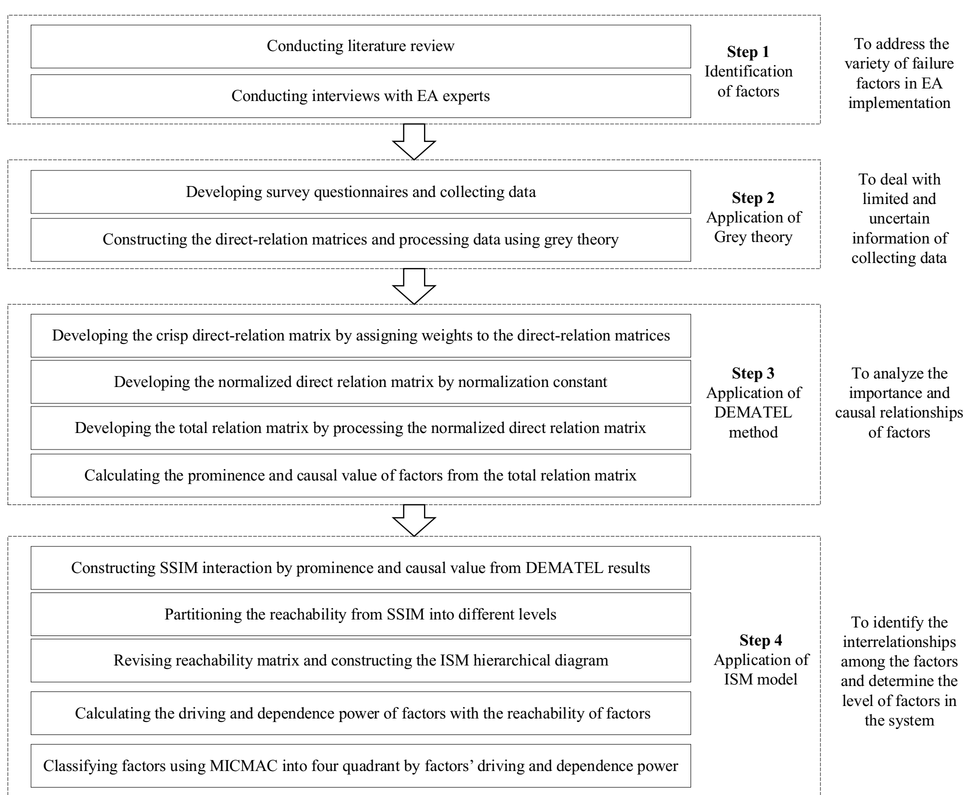


Fig. 1 Flow chart for grey-DEMATEL-ISM approach

- Step 2c: Calculate the total normalized crisp value using formula (5) after the grey number is normalized:

$$Y_{ij}^{k} = \frac{\underline{\otimes}\bar{x}_{ij}^{k}\left(1 - \underline{\otimes}\bar{x}_{ij}^{k}\right) + \overline{\otimes}\bar{x}_{ij}^{k} \times \overline{\otimes}\bar{x}_{ij}^{k}}{1 - \underline{\otimes}\bar{x}_{ij}^{k} + \overline{\otimes}\bar{x}_{ij}^{k}} \tag{5}$$

- Step 2d: Calculate the final crisp value by formula (6).

$$Z_{ij}^{k} = \min_{j} \underline{\otimes} x_{ij}^{k} + Y_{ij}^{k}\Delta_{min}^{max} \tag{6}$$

Step 3 Conduct the DEMATEL analysis. This step has five tasks.

- Step 3a: Assign weights to respondents based on their expertise and experience. Initially, the weights of each of the experts were equally assigned, as the experts were selected for their profound knowledge of the area. The weighted average method is applied to come up with an overall crisp direct-relation matrix O from the individual direct-relation matrices A (described in Step 1).
- Step 3b: Develop the normalized direct relation matrix (N) by multiplying the matrix O using a normalization factor K, which is the minimum value of the inverse of the max of the sum of a row. Then calculate the total relation matrix T by multiplying N with the inverse matrix of the difference of N and the identity matrix.

$$N = K * B \tag{7}$$

$$\text{Where } K = \frac{1}{\max_{1 \le i \le I} \sum_{j=1}^{J} b_{ij}} \tag{8}$$

$$T = N(\bar{I} - N)^{-1} \tag{9}$$

where $\bar{I}$ represents the identity matrix.

- Step 3c: Calculate the causal parameters "R" and "D" defining the summation of all the rows and summation of all the columns for each of the variables in Matrix T.

$$R = \left[\sum_{j=1}^{J} t_{ij}\right]_{J \times 1} \tag{10}$$

$$D = \left[\sum_{i=1}^{I} t_{ij}\right]_{1 \times I} \tag{11}$$

- Step 3d: For a given factor, calculate its R + D and R-D. R + D is called "prominence value" which denotes the total effect received or given by any factor. R-D is called "causal value" which indicates to what extent a factor is influencing (or being influenced by) other factors. The prominence value represents the importance of a factor on the entire system. The greater the value of the prominence value, the greater the overall prominence (i.e., the influence or importance) of a factor in terms of its overall relationships with other factors. The causal value depicts the net causality of the factors. Factors can be divided into the cause group or effect group based on their causal value. If the causal value of a factor is positive, then the factor belongs to the cause group, which means it is the cause or the foundation for other factors. If the causal value of a factor is negative, then it belongs to the effect group, which means the factor is the effect of other factors. Then use prominence value and causal value as x-axis and y-axis to develop the prominence-causal diagram. Thereafter perform the principal component analysis to derive factors for both causal and effect factors.
- Step 3e: Conduct sensitivity analysis. We carried out the initial calculation by assigning equal weights to all the experts. However, results may suffer from biases due to the difference in their expertise and experience. To check the robustness of the results, we carried out a sensitivity analysis to check if there is a significant change in the pattern of the responses depending on different weights given to the experts. We generated four different scenarios by significantly changing the level of weight assigned to different experts.

Step 4 Conduct the ISM analysis using five tasks.

- Step 4a: Develop a structural self-interaction matrix (SSIM), indicating the pairwise relations between the factors. SSIM is developed from the decision-making matrix with the partially ordered sequential rule. Numbers from 1 to i of factors are the row of decision-making matrix, while the R + D and R-D are the columns of the matrix. The partially ordered sequential rule is:

$$a_{xy} = \begin{cases} 1, x > y \\ 0, others \end{cases} \tag{12}$$

Where a_{xy} is the value of SSIM.

- Step 4b: Develop the reachability matrix R from the SSIM matrix and checking it for transitivity.

$$R = SSIM + \bar{I} \tag{13}$$

The transitivity of the interrelation among the factors is a basic assumption in the ISM model. The transitivity principle states that if factor A is linked to factor B and factor B is linked to factor C, then factor A is inevitably linked to factor C.

- Step 4c: Formulate reachability and antecedent sets for each factor. A reachability set consists of all the factors that are driven by the variable under consideration, whereas the antecedent set comprises all the factors that drive it. The common elements of these sets constitute an intersection set. Suppose the elements of intersection and reachability set for any factor are the same. In that case, the factor becomes the top-level factor in the ISM hierarchy (Based on the rule of alternate priority of reachability and antecedent). This top-level factor is then separated from other factors. This level partitioning process is repeated until all levels are obtained.
- Step 4d: Based on the partition level, generate a resultant diagram, and remove the transitive links by taking into account the transitivity's rule. The transitivity's rule comes from the skeleton matrix S.

$$S = R - \left(R - \bar{I}\right)^2 - \bar{I} \tag{14}$$

The final diagram is converted into an ISM hierarchical structure by replacing the barrier nodes with statements.

- Step 4e: Conduct the cross-impact matrix multiplication applied to classification (MICMAC) analysis and establish the driving power and the dependency of the selected factors. The MICMAC principle is based on the multiplication properties of matrices stating that if a factor A affects factor B, which, in turn, directly influences factor C, then any change affecting A may have repercussions on C.

3.3 Data Collection

This study employs the methodology proposed in the previous section for analyzing the 15 factors influencing EA failure. Based on these factors, a DEMATEL-based questionnaire matrix was developed (Step 1) and shared with 8 EA experts. Table 3 provides an overview of the experts' background and experience. They were selected for their variety of experiences in different industries.

Table 3 Background and experience of EA experts

	Industry	Years of experience
Expert 1	Government	20
Expert 2	Automobile industry	15
Expert 3	Food industry	10
Expert 4	Finance	8
Expert 5	Manufacturing and logistics	9
Expert 6	Apparel Industry	8
Expert 7	Telecommunications	15
Expert 8	Academia	16

4 Analysis and findings

4.1 Grey-DEMATEL Analysis

For analyzing the interrelationship of the factors, we first introduced our study and explained the factors, as listed in Table 1, to the experts one by one. Thereafter, we asked them to complete a direct-relation matrix by indicating their opinions about the degree of influence between factors by using a five-level measurement from "no influence" to "very high influence" (see Table 2). Their personal views relating to these factors were also captured after they filled in the matrix.

Then for each of the expert inputs, in total, 8 crisp matrices Z is formed in Step 2. Each experts' input is equally important for the analysis of the factors. Therefore, equal weight is assigned to the 8 experts, which is 0.125. By using the weighted average method and conducting Step 3a and 3b, the normalized direct relation matrix N and the total relation matrix T are provided in Tables 4 and 5.

According to Step 3c and 3d, prominence value (Ri + Di) and causal value (Ri-Di) are provided in Table 6. Based on the results of prominence value, the order of importance of the factors is as follows: F6>F7>F4>F2>F5>F9>F13>F12>F1>F15>F3>F14>F10>F8>F11. There are nine factors with prominence values over the collective average (P =3.5510) of the group: F6, F7, F4, F2, F5, F9, F13, F12 and F1. These are high prominence factors which are more important than low prominence factors. The factors can be categorized into a cause or effect group based on the value of causal value: factors with positive or negative causal values fall under a cause or effect group respectively. In Table 7, they are ranked according to their prominence and causal value from high to low, and they are divided into high prominence or low prominence group and into cause group or effect group. A prominence–causal diagram shown in Fig. 2 further demonstrates the data distribution on a two-dimensional axis. The X-axis represents the prominence value, while the Y-axis represents the causal value of factors.

Based on Step 3e, we carried out a sensitivity analysis. We generated four different scenarios by significantly changing the levels of weight assigned to different experts. Table 8 shows the assigned weights for sensitivity analysis in each scenario. Figure 3 presents the results of sensitivity analysis. By this sensitivity analysis, we found that the

Table 4 The normalized direct relation matrix N

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	0.0000	0.0739	0.0792	0.0894	0.0317	0.0439	0.0488	0.0691	0.0839	0.0345	0.0490	0.0997	0.0378	0.0244	0.0223
F2	0.0234	0.0000	0.0124	0.0837	0.0569	0.0634	0.0601	0.0585	0.0733	0.0492	0.0242	0.0563	0.0386	0.0293	0.0280
F3	0.0595	0.0837	0.0000	0.0991	0.0325	0.0634	0.0788	0.0788	0.0938	0.0695	0.0618	0.1051	0.0435	0.0228	0.0329
F4	0.0136	0.0228	0.0075	0.0000	0.0325	0.0171	0.0382	0.0536	0.0741	0.0591	0.0126	0.0268	0.0118	0.0057	0.0167
F5	0.0353	0.0683	0.0183	0.0683	0.0000	0.0585	0.0934	0.0390	0.0528	0.0335	0.0223	0.0439	0.0540	0.0886	0.0638
F6	0.0804	0.0983	0.0449	0.0886	0.0634	0.0000	0.1081	0.0349	0.0843	0.0646	0.0526	0.0691	0.0689	0.0683	0.0737
F7	0.0648	0.0829	0.0191	0.0991	0.0683	0.0683	0.0000	0.0439	0.0737	0.0492	0.0433	0.0739	0.0485	0.0479	0.0388
F8	0.0225	0.0122	0.0167	0.0683	0.0219	0.0171	0.0382	0.0000	0.0490	0.0286	0.0077	0.0374	0.0126	0.0122	0.0118
F9	0.0130	0.0374	0.0167	0.0479	0.0171	0.0471	0.0431	0.0423	0.0000	0.0481	0.0223	0.0423	0.0232	0.0179	0.0183
F10	0.0398	0.0431	0.0118	0.0642	0.0163	0.0333	0.0341	0.0333	0.0483	0.0000	0.0169	0.0431	0.0282	0.0122	0.0134
F11	0.0185	0.0276	0.0187	0.0585	0.0163	0.0276	0.0382	0.0829	0.0532	0.0280	0.0000	0.0187	0.0077	0.0114	0.0118
F12	0.0236	0.0382	0.0284	0.0943	0.0276	0.0431	0.0585	0.0634	0.0786	0.0729	0.0495	0.0000	0.0234	0.0179	0.0282
F13	0.0597	0.0634	0.0390	0.0796	0.0837	0.0390	0.0553	0.0488	0.0392	0.0437	0.0217	0.0333	0.0000	0.0886	0.0737
F14	0.0496	0.0626	0.0282	0.0691	0.0683	0.0488	0.0593	0.0439	0.0490	0.0532	0.0126	0.0333	0.0752	0.0000	0.0640
F15	0.0557	0.0585	0.0293	0.0439	0.0634	0.0536	0.0544	0.0585	0.0392	0.0494	0.0223	0.0431	0.0849	0.0634	0.0154

Table 5 The total relation matrix T

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	0.0733	0.1719	0.1245	0.2308	0.1116	0.1290	0.1573	0.1710	0.2077	0.1335	0.1067	0.1947	0.1082	0.0890	0.0888
F2	0.0866	0.0876	0.0540	0.2007	0.1247	0.1329	0.1511	0.1409	0.1752	0.1301	0.0719	0.1364	0.1004	0.0878	0.0868
F3	0.1420	0.1972	0.0577	0.2622	0.1259	0.1602	0.2011	0.1950	0.2359	0.1803	0.1272	0.2145	0.1254	0.0987	0.1093
F4	0.0489	0.0711	0.0306	0.0696	0.0695	0.0589	0.0890	0.0996	0.1300	0.1031	0.0396	0.0738	0.0469	0.0383	0.0483
F5	0.1122	0.1711	0.0685	0.2092	0.0885	0.1441	0.1988	0.1389	0.1746	0.1305	0.0789	0.1411	0.1312	0.1563	0.1340
F6	0.1755	0.2303	0.1095	0.2733	0.1720	0.1162	0.2453	0.1693	0.2436	0.1892	0.1264	0.1970	0.1659	0.1570	0.1621
F7	0.1404	0.1882	0.0727	0.2463	0.1535	0.1567	0.1186	0.1514	0.2035	0.1512	0.1028	0.1748	0.1263	0.1198	0.1120
F8	0.0550	0.0587	0.0385	0.1303	0.0580	0.0558	0.0860	0.0466	0.1048	0.0731	0.0342	0.0812	0.0453	0.0418	0.0421
F9	0.0567	0.0952	0.0444	0.1293	0.0647	0.0942	0.1045	0.0989	0.0725	0.1025	0.0550	0.0973	0.0652	0.0565	0.0575
F10	0.0798	0.0993	0.0405	0.1433	0.0629	0.0807	0.0949	0.0907	0.1185	0.0559	0.0497	0.0980	0.0684	0.0500	0.0517
F11	0.0551	0.0773	0.0427	0.1294	0.0567	0.0697	0.0919	0.1311	0.1154	0.0768	0.0286	0.0691	0.0439	0.0438	0.0448
F12	0.0817	0.1172	0.0655	0.2028	0.0908	0.1090	0.1417	0.1420	0.1745	0.1470	0.0926	0.0782	0.0801	0.0695	0.0799
F13	0.1357	0.1690	0.0897	0.2228	0.1677	0.1282	0.1676	0.1517	0.1657	0.1418	0.0795	0.1349	0.0819	0.1581	0.1446
F14	0.1220	0.1616	0.0764	0.2043	0.1484	0.1313	0.1638	0.1399	0.1663	0.1442	0.0677	0.1284	0.1465	0.0714	0.1311
F15	0.1307	0.1615	0.0801	0.1867	0.1470	0.1383	0.1631	0.1568	0.1608	0.1434	0.0788	0.1405	0.1583	0.1340	0.0877

pattern of all the factors is similar for all the scenarios with small deviations. This indicates that our results are robust and there is consensus among the experts towards the relationships of the factors.

4.2 ISM Analysis

In order to further explain the relationship chains between factors based on the results obtained from the grey-DEMATEL, we conducted the ISM analysis to investigate further the correlations which contained direction and level among the factors. Based on Step 4a and 4b, the pairwise relationships were recorded, and the SSIM and the reachability matrix R (shown in Table 9) were created.

The reachability sets and antecedent sets are derived from the reachability matrix, and the level partitioning summary is presented in Table 10 according to Step 4c, with details in Table 11, Appendix 1. Figure 4 is the ISM which presents the causal relationships among the factors based on Step 4d. The results indicate that factors from Level 1 to Level 3 have

Table 6 The values of prominence and causal value

	R	D	R+D	R-D
F1	2.0980	1.4958	3.5938	0.6022
F2	1.7673	2.0574	3.8247	-0.2900
F3	2.4327	0.9952	3.4279	1.4374
F4	1.0172	2.8409	3.8581	-1.8236
F5	2.0780	1.6419	3.7198	0.4361
F6	2.7325	1.7051	4.4376	1.0275
F7	2.2182	2.1748	4.3929	0.0434
F8	0.9511	2.0238	2.9749	-1.0728
F9	1.1945	2.4490	3.6435	-1.2544
F10	1.1843	1.9025	3.0868	-0.7182
F11	1.0763	1.1395	2.2158	-0.0633
F12	1.6725	1.9599	3.6324	-0.2874
F13	2.1389	1.4939	3.6328	0.6451
F14	2.0032	1.3720	3.3752	0.6312
F15	2.0676	1.3807	3.4483	0.6868

met with factors (F3, F6, F15, F13, F14, F1, F5 and F7) in the cause group of ISM, and factors from Level 3 to Level 5 have met with factors (F11, F12, F2, F10, F8, F9 and F4) in the effect group of ISM. The results verify the consistency of the DEMATEL-ISM methods in their combination.

The MICMAC analysis aims to analyze the driving power and dependence power of the factors. Driving power means the total ability of a factor to influence other factors, while dependence power means the total ability of a factor to be affected by other factors. These two kinds of power do not conflict with the importance of a factor (reflected by its prominence value). A factor having a high prominence value could be affected by other factors. Similarly, a factor with a low prominence value could also affect others. The factors are classified into four categories, autonomous, dependent, linkage and independent. Based on Step 4e, the MICMAC analysis result is shown in Fig. 5. The factors having weak driving power and weak dependence power are presented in

Table 7 The rankings and categories of factors based on their prominence and causal value

High prominence		Low prominence		Cause group		Effect group	
Factors	Prominence	Factors	Prominence	Factors	causal value	Factors	causal value
F6	4.4376	F15	3.4483	F3	1.4374	F11	-0.0633
F7	4.3929	F3	3.4279	F6	1.0275	F12	-0.2874
F4	3.8581	F14	3.3752	F15	0.6868	F2	-0.2900
F2	3.8247	F10	3.0868	F13	0.6451	F10	-0.7182
F5	3.7198	F8	2.9749	F14	0.6312	F8	-1.0728
F9	3.6435	F11	2.2158	F1	0.6022	F9	-1.2544
F13	3.6328			F5	0.4361	F4	-1.8236
F12	3.6324			F7	0.0434		
F1	3.5938						

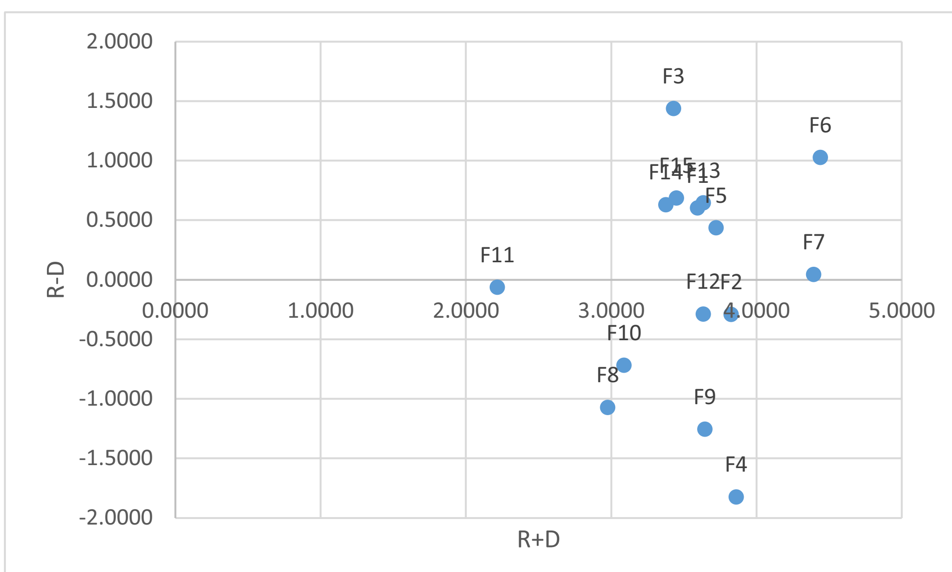


Fig. 2 Prominence–causal diagram

Table 8 The weights of experts assigned to different scenarios

	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Expert8
Basic scenario	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Scenario1	0.1	0.1	0.1	0.1	0.15	0.15	0.15	0.15
Scenario2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Scenario3	0.15	0.15	0.15	0.15	0.05	0.05	0.15	0.15

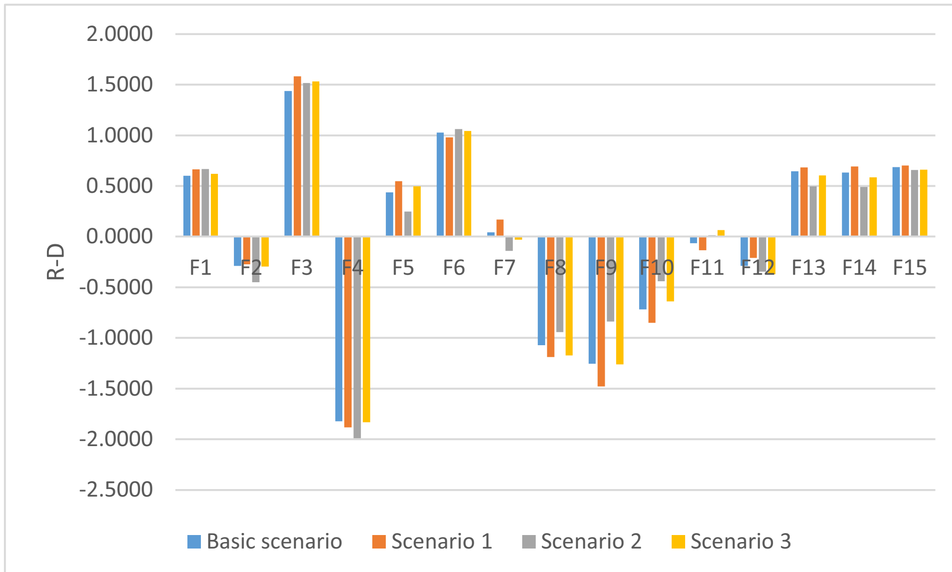


Fig. 3 Sensitivity analysis using the four scenarios

Table 9 Reachability matrix R

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
F1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0
F2	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0
F3	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0
F4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
F5	0	0	0	0	1	0	0	1	1	1	1	1	0	0	0
F6	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
F7	0	1	0	1	0	0	1	1	1	1	1	1	0	0	0
F8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
F9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
F10	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
F11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
F12	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0
F13	1	0	0	0	0	0	0	1	0	1	1	1	1	1	0
F14	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0
F15	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1

Quadrant I, autonomous. F1, F2, F3, F4, F5, F7, F9, F12, F13, F14, F15 are belong to this category. The main characteristic of these factors is that they may have a few links that might be strong and do influence the structure much. Quadrant II is the dependent category, whereas F8, F10 and F11 are the dependent factors in our study, which possess weak driving power but strong dependence power. Quadrant III is the linkage category, possesses strong driving power and strong dependence power. There is no linkage factor in our study, which implies that the developed model is quite stable. Quadrant IV is the independent category that has strong driving power but weak dependence. F6 is the only factor in this quadrant, and therefore, it is the driving factor or the root cause.

Table 10 Level partitioning summary

	Reachability Set	Antecedent Set	Intersection Set	Level
F3	3,8,10,11	3	3	L1
F6	1,2,4,5,6,7,8,9,10,11,12,13 ,14,15	6	6	L1
F5	5,8,9,10,11,12	5,6	5	L2
F7	2,4,7,8,9,10,11,12	6,7	7	L2
F13	1,8,10,11,12,13,14	6,13	13	L2
F15	8,10,11,14,15	6,15	15	L2
F1	1,8,10,11	1,6,13	1	L3
F2	2,8,9,10	2,6,7	2	L3
F12	8,10,12	5,6,7,12,13	12	L3
F14	8,10,11,14	6,13,14,15	14	L3
F10	8,10	1,2,3,5,6,7,10,12,13,14,15	10	L4
F4	4	4,6,7	4	L5
F8	8	1,2,3,5,6,7,8,10,12,13,14,15	8	L5
F9	9	2,5,6,7,9	9	L5
F11	11	1,3,5,6,7,11,13,14,15	11	L5

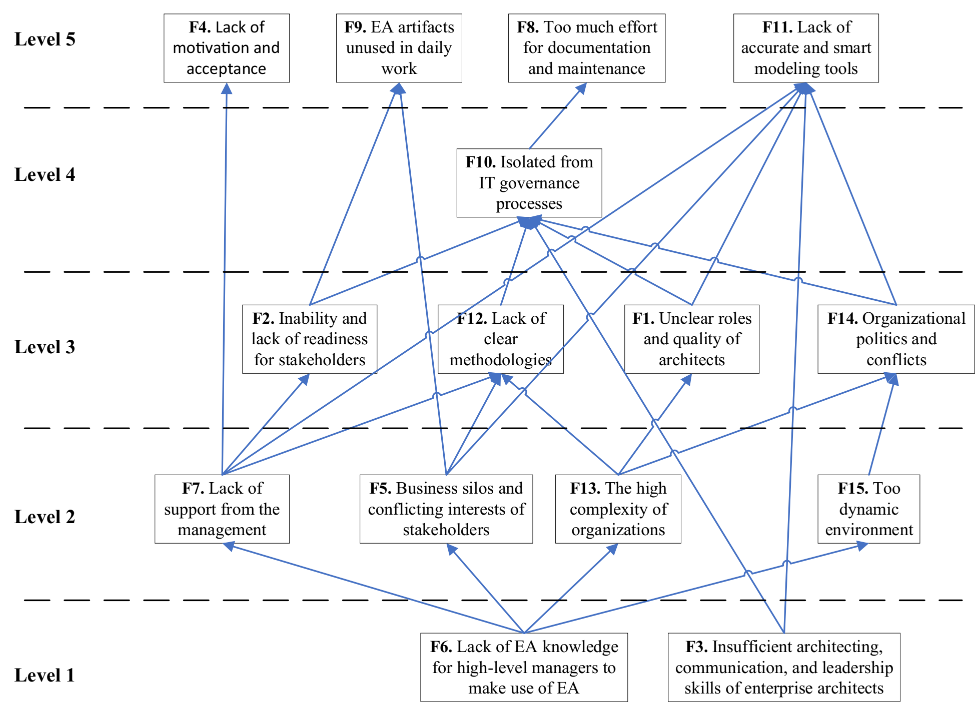


Fig. 4 ISM model depicting the causal relationships among the factors

5 Discussion

This study explores the factors influencing the failure of EA implementation and their relationships. Our analysis further shows that those factors are not in isolation and do not have the same importance. We considered the complex and interwoven relationships among factors and focused on the causal analysis by employing the grey-DEMATEL-ISM approach.

The DEMATEL analysis generates both the value of prominence and causal value (the "R + D" and "R-D" in Table 6) of each factor. The value of prominence reflects to what extent a factor can affect the system as a whole, i.e., the importance of factors to the failure of overall EA implementation. It is the measure to determine whether a factor should be considered as a key factor. The causal value determines a factor to be a causal factor or effect factor. The causal factors affect the effect factors. In contrast, ISM and MICMAC

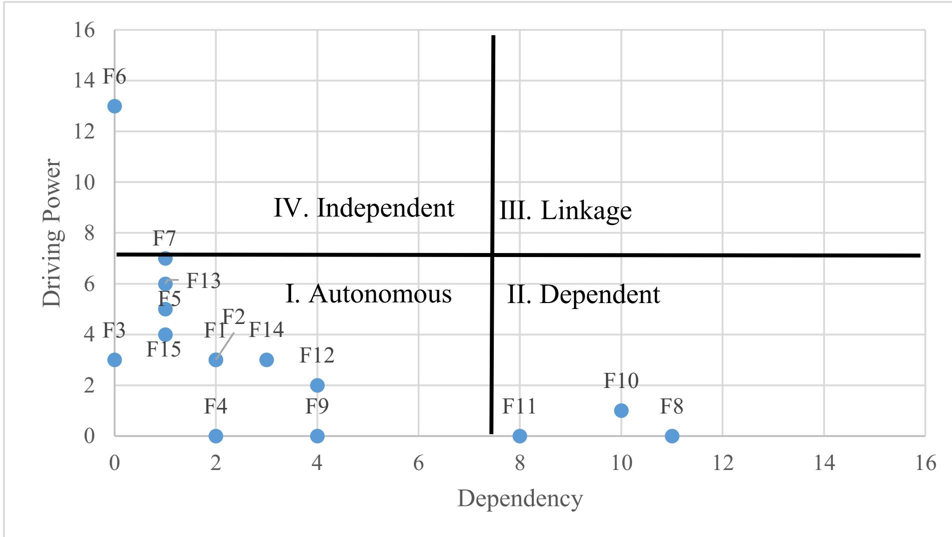


Fig. 5 Driving power and dependence diagram

analysis focus on the complex relationships between factors. From DEMATEL to ISM and then MICMA analysis, it is a progressive process. The effect factors (F11, F12, F2, F10, F8, F9, and F4) can be found from Level 3 to 5 in the result of the ISM analysis, while the causal factors (F3, F6, F15, F13, F14, F1, F5, and F7) locate on Level 1 to 3. At the same time, in the results of MICMAC analysis, all causal factors are with low dependency while all effect factors are with low driving power. The above cross-checks reflect the compatibility between DEMATEL and ISM or MICMAC analysis. This compatibility enables the understanding and discussion of each factor from its prominence or causal value, or its location in the ISM results.

5.1 Discussion of DEMATEL Results

The results of grey-DEMATEL show that when the factors with higher prominence (with a prominence value higher than the average value), i.e., F6, F7, F4, F2, F5, F9, F13, F12, and F1 are observed, it alters EA practitioners to the co-existing of other factors and the possibility of EA failure. In this case, practitioners should review their EA initiatives with the rest causal factors, i.e., F3, F15, F14, F1, and F5, to evaluate the risk of their EA implementation. These factors could work as a quick checking list to help practitioners in self-evaluation and improvement.

Combining the Tables 6 and 7, and Fig. 2, the discussion on the prominence and causal value of factors reveals four insights. First, the factors with high prominence value and positive causal value have both a great effect on the whole system and other factors. EA practitioners should prioritize these factors, such as F6 and F7 and F5, F13, and F1. The findings show that strong leadership integrated with EA initiatives is crucial. This requires high-level managers to have sufficient knowledge to use EA (F6) in their decision-making processes and continuously support the EA initiatives (F7). Business silos and the conflicting interests of stakeholders (F5) also hinder the implementation of EA initiatives. This implies the need for communications and coordination efforts in EA implementation (Banaeianjahromi & Smolander, 2019). Similar to the findings from studies on general IT project failures (Daniels & LaMarsh, 2007; Lu et al., 2010; Nelson, 2007; Pinto & Mantel, 1990; Yeo, 2002), environmental complexity also largely impacts EA implementation. In such an environment with organizational complexities and conflicting interests, clarifying the roles of enterprise architects becomes a challenge (F1), supporting the claims made in the previous study that organizations often lack an agreement about the roles of enterprise architects (Walrad et al., 2014).

Second, factors with a low prominence value but positive causal value, such as F15, impact EA implantation via other factors with negative causal value. In addressing those factors, EA practitioners should also consider their relationships with other effect factors. EA should be able to deal with a complex landscape of systems that is also with high dynamic. Our study found that environmental dynamic (F15) is an underlying cause of EA failure. One expert formulated this as "*EA was initiated 2 years ago … it now appears that it has become so complex due to all the different links and components that the cause of the malfunction cannot be found anymore*". The paradox is that EA is an instrument to deal with the dynamic of the environment, but it fails due to the same dynamic. This finding suggests that there are limits to the complexity and dynamic that an organization can handle, despite the various instruments to deal with them. The dynamic of the environment is difficult to address or even not impossible at all. For improvement, EA practitioners could consider addressing organizational politics and their conflicts (F14) which is influenced by F15. This finding is aligned with the findings from previous studies in the public sector (Ajer et al., 2021; Kurnia et al., 2021).

Third, factors with high prominence value but negative causal value, such as F4, F2, F9, and F12, are relevantly important but passive. These factors should be treated with consideration on their importance to the EA implementation and what are the factors that influence them. EA initiatives need extensive collaboration with IT personnel and various stakeholders. This requires motivation and acceptance among IT personnel (F4) which could be influenced by the attitude and support from management (F7). This confirms the finding from a previous study that the lack of support in an organization will result in the lack of motivation among personnel (Banaeianjahromi & Smolander, 2019). Another example is that the unused EA artifacts in daily work (F9) reflect stakeholders' lack of readiness (F2) to join EA initiatives.

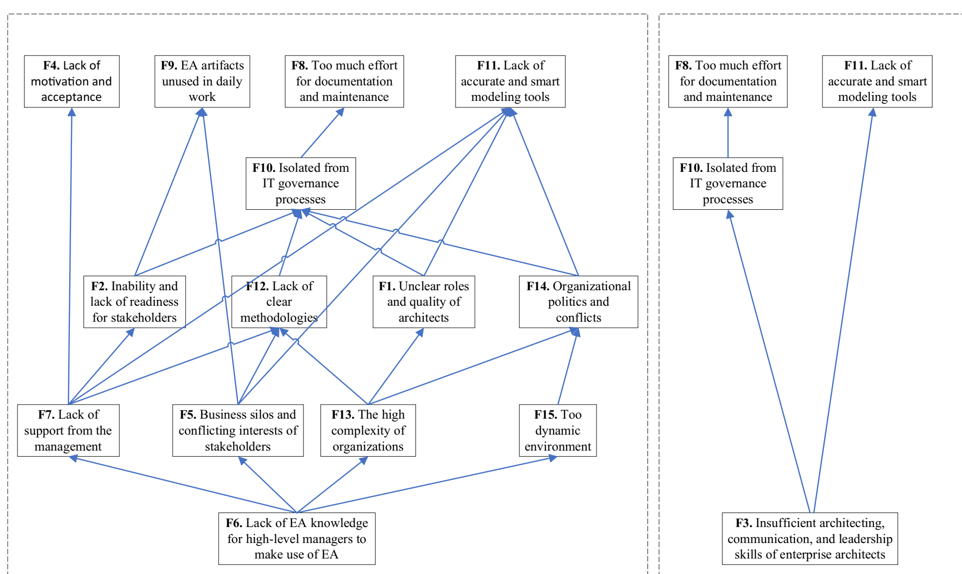
Fourth, factors with low prominence value and negative causal value, e.g., F10, F8, and F11, can be given less priority in improving EA practice. They appear to be less relevant. Improvement of those factors will not bring much value to EA implementation, if the factors influencing them are not actually improved.

The above discussion reveals that some factors have a direct influence to the failure of EA implementation and can generate influence via other factors. These findings reflect that EA implementation is complex in nature, which findings supports the claims made in the previous studies (Gong & Janssen, 2019; Iyamu, 2019). By analyzing ISM results, the interrelationships between the variety of factors associated with failure of EA implementation revealed a comprehensive conceptualization that did not yet exist in existing research.

5.2 Discussion of ISM Results

The ISM model distinguished the hierarchy of factors and identified which factors should be chosen to address EA failure problems and improve EA practice. We divided the model into two sub-models (. 6), reflecting from the perspective of high-level managers or architects, to further investigate and elaborate on the causal mechanism of EA failure.

High-level managers, such as the CIOs, having sufficient EA knowledge is crucial to the success of EA initiatives. Having limited EA knowledge (F6), high-level managers may not understand the real benefits of EA, and consequently, they will not provide sufficient support (F7) to prioritize the EA development and to assign enough budget and resources (Banaeianjahromi & Smolander, 2019). CIOs function as boundary spanners between IT and business and should ensure the development of IT infrastructure and functionalities could break business silos and properly address conflict interest among stakeholders (F5). Furthermore, managers should ensure the translation of strategy into IT projects in a dynamic environment (F15) and ensure that the IT landscape is prepared for this complexity and dynamics (F13). High-level managers with this role in their work need help with their EA knowledge (Gonzalez et al., 2019). There is a gap between the knowledge of CIOs and enterprise architects (Gong et al., 2019). High-level managers are suggested to collaborate closely with enterprise architects to ensure EA is properly used in decision-making processes (Pang et al., 2016). Improving the high-level management's learning and understanding of EA has become imperative for further improving EA practice and reducing the risk of EA failure at the root.



(a) The sub-model for the perspective of high-level managers

(b) The sub-model for the perspective of architects

Fig. 6 The submodel reflecting from the perspective of high-level managers and architects

In sub-model (a), F4, F9 and F8 are at the top level with large dependences on other factors. Simply improving those factors will not change the whole system in essence. Especially for F4 and F9, having a high prominence value reflects their high importance in the opinions of the experts. But the efforts for improving them might not work if their underlying causing factors (i.e., F7, F2, and F5) have not been properly addressed.

From the perspective of the architect, presented in the sub-model (b), EA initiatives can be highly complex and require a high level of skills in architecting, communication, and leadership (F3). If architects are not competent in architecting, it might result in inaccurate modeling and inefficient use of architecting tools (F11). When architects do not possess sufficient communication and leadership skills, they conduct the EA function in isolation and are not able to follow IT governance processes (F10). In the end, this results in too much effort for developing the initial EA documentation and further maintenance (F8).

5.3 Discussion of MICMAC Results

Based on the interrelationships of factors from the ISM analysis, we conducted a MICMAC analysis to calculate the driving power and the dependency of each factor, presented in Fig. 5 with four quadrants (Attri et al., 2013; Sharma et al., 2021). In this section, we discussed the influence of factors in different quadrants on EA implementation.

(1) *Autonomous quadrant*: Autonomous factors generally appear as weak drivers and weak dependents, which means they are relatively disconnected from the system. These factors do not have much influence on the other factors of the system. Figure 5 presents many autonomous factors, indicating that architects often overlook them. However, the ISM analysis reflects the complex and interwoven causal chains among all the factors. If a causal chain has not been carefully addressed with the proper improvement of those autonomous factors, the risk of EA implementation failure cannot be relieved. EA is a very complex system by nature (Ajer et al., 2021). Autonomous factors can be assigned with lower priorities because of their weak driving and dependence power, but they cannot be ignored.

(2) *Dependent quadrant*: F11, F10 and F8 are weak drivers but strong dependent factors. They are situated further up the ISM hierarchy (see Fig. 4). These factors represent the symptoms of any unsuccessful EA implementation and are classified largely as dependent factors. Hence, EA practitioners should take special care to handle these factors.

Actually, despite the hierarchical crossing principle of ISM (if a factor is not affected by any other factor, it should be at the bottom; if a factor does not affect any other factor, it should be at the top), the position of F4 should level down to Level 3. Likewise, F9 should level down to Level 4. In this way, they are only the dependent factors for the sub-model for high-level manager's perspective, but not for the whole model. This implies that F4 and F9 are not in the dependent quadrant but the autonomous quadrant

(3) *Linkage quadrant*: No factors fall in the linkage quadrant in the current model. This quadrant is primarily known for strong driving power and strong dependence power. Therefore, it implies that the developed model is quite stable (Kamble et al., 2020).

(4) *Independent quadrant*: F6 is the only one in the independent quadrant in Fig. 5, and it is at the bottom of the ISM model (Fig. 4) with strong driving power. Addressing this factor will essentially improve the EA implementation management to enhance the chance of success and are classified as independent factors or drivers. Therefore, this factor needs consistent attention from practitioners focused on improving EA implementation. Furthermore, despite the hierarchical crossing principle of ISM, the position of F3 should level up to Level 3 because it is only the root factor in the sub-model for the architect's perspective, not the whole model. It implies that F3 does not fall in this quadrant but in the autonomous quadrant. This reflects that architects should pay more attention to F3 than high-level managers.

6 Contributions and Limitations

6.1 Theoretical Contributions

The findings of this study provide both theoretical and practical contributions. EA research has stumbled upon a fundamental problem of lacking explanatory theory in the field of EA (Tamm et al., 2011). The existing EA literature does not explain clearly what theoretical mechanisms enable EA to create value, in which circumstances they may not work as expected, and why EA practices in organizations often fail (Kotusev & Kurnia, 2021). The causal mechanism of EA failure we discovered in this study could provide insights and coherent understanding for the theory-building to explain EA success or failures phenomena. For example, stakeholder involvement is widely recognized as a critical success factor of EA implementation (Kurnia et al., 2021; Schmidt & Buxmann, 2011; Wood et al., 2013), but the literature does hardly explain why stakeholder involvement is so critical in EA practice (Kotusev & Kurnia, 2021). Our causal model reveals that the lack of stakeholder involvement will cause several problems. EA artifacts are unused in daily work, isolating EA from IT governance processes, and resulting in too much effort for EA documentation and maintenance. This coherent understanding goes beyond the indication of various but fragmented success factors or pitfalls of EA practices. Furthermore, the findings of this study demonstrate that different factors actually impede the success of EA implementation and their relationships are often invisible. This provides a different but significant theoretical lens to understand the relevance and importance of various factors in EA practice. To the best of our knowledge, this is the first study in the field that comprehensively identifies and links fifteen factors related to the failure of EA implementation. The formal development of these links and further predictive causal links between factors identified in this research can be considered a significant contribution in this area.

A further key theoretical contribution is in the method adopted, being the first study to utilize grey-DEMATEL-ISM approach. Grey systems theory deals with the uncertainty of EA failure opinions with knowledge and experience of experts through generating, excavating, and extracting useful information from available but limited data provided by the experts. DEMATEL first calculates the importance of factors and divides the factors into “causal factors” and “effect factors”. The ISM model determines the links between factors that affect EA failure and assesses how these links are represented in the perspective of their driving and dependence power in relation to the other factors. The hierarchy or level of factors presented in the ISM-based model indicates the relative importance of different factors as drivers, relatively dependent factors somewhere in the middle across the levels. The ISM-based model also provides the correlations between the factors presented at the five levels. These will help researchers to select these factors for further framework development and validation.

6.2 Practical Contributions

Reflecting on practical contributions, the findings of this study can serve as a checking list and causal diagram for those EA practitioners who implement EA projects and lack prior perceived knowledge about EA implementation. The results of DEMATEL in our study could work as a quick checking list to help practitioners in self-evaluation and improvement. ISM also helps in classifying factors into autonomous, dependent, linkage, and independent categories. Management may use their resources towards the identified factors among these categories to accomplish the optimization of resources. Moreover, the ISM model provided in this study has a widespread application and can be used to improve EA’s effectiveness, performance, and managing abilities towards a successful EA implementation.

Our study for identification and ranking of factors influencing EA failure provides practitioners a more realistic representation of the problem in EA implementation. The utility of the proposed method lies in imposing order and direction on the complexity of relationships among these factors, which would help practitioners to better utilize their resources for maximizing the EA initiatives. The ISM model allows practitioners to effectively incorporate these factors at an early stage, which can help to avoid failure of EA implementation.

6.3 Limitations and Future Research

This study has several limitations. The first restriction is about the selection of EA experts. All invited experts in this study are from China or the Netherlands, which may not provide sufficient representativeness in geographical distributions. Although we try to increase industrial diversity by inviting EA experts from different industries, the limited number of respondents restricts the involvement of industries. Future research could consider this limitation and invite experts from more countries and industries and analyze if culture and industries influence the outcomes. Second, to explore the reasons behind EA failure, we invited only EA experts to provide input. This approach might result in biases to the role of high-level managers, such as the CIOs. To some extent, this study reflects the influence and duty of CIOs in EA implementation from an enterprise architects’ viewpoint. Future research can examine the opinions of high-level managers to detect whether there are conflicts in the beliefs and perceptions of EA implementations between, for example, architects and CIOs. The third restriction is about the outcome of the ISM analysis. Figure 4 presents a complex causal model of the factors, but those causal chains in the models should be further investigated to confirm and elaborate on them. Therefore, we recommend case studies in the future for investigation and theory building.

7 Conclusions

EA initiatives are prone to failure and therefore understanding the factors influencing the failure of EA initiatives is paramount. Using systematic literature review we identified 15 factors and invited 8 EA experts to evaluate their influence on each other. The grey-DEMATEL-ISM approach was employed to analyze the experts’ input. The findings show that the factors are correlated and interwoven in complex causal chains. This study reveals that enhancing high-level managers’ EA knowledge is crucial to avoiding EA failure because it will influence most other factors directly or indirectly. At the same time, architects should invest in their architecting, communication, and leadership skills which will enhance their performances in EA modeling, documentation, and maintenance, and enable the combination of EA functions with IT governance processes. This study helps practitioners improve their EA initiatives by providing a comprehensive understanding of EA failure factors. It also lays a foundation for future theory buildings and developing a causal relationship model to explain EA mechanisms.

Appendix 1

Table 11 Level partitioning in details

Round 1				
	R	A	T	Level 1
F1	1,8,10,11	1,6,13	1	
F2	2,8,9,10	2,6,7	2	
F3	3,8,10,11	3	3	F3
F4	4	4,6,7	4	
F5	5,8,9,10,11,12	5,6	5	
F6	1,2,4,5,6,7,8,9,10,11,12,13,14,15	6	6	F6
F7	2,4,7,8,9,10,11,12	6,7	7	
F8	8	1,2,3,5,6,7,8,10,12,13,14,15	8	
F9	9	2,5,6,7,9	9	
F10	8,10	1,2,3,5,6,7,10,12,13,14,15	10	
F11	11	1,3,5,6,7,11,13,14,15	11	
F12	8,10,12	5,6,7,12,13	12	
F13	1,8,10,11,12,13,14	6,13	13	
F14	8,10,11,14	6,13,14,15	14	
F15	8,10,11,14,15	6,15	15	
Round 2				
	R	A	T	Level 5
F1	1,8,10,11	1,13	1	
F2	2,8,9,10	2,7	2	
F4	4	4,7	4	F4
F5	5,8,9,10,11,12	5	5	
F7	2,4,7,8,9,10,11,12	7	7	
F8	8	1,2,5,7,8,10,12,13,14,15	8	F8
F9	9	2,5,7,9	9	F9
F10	8,10	1,2,5,7,10,12,13,14,15	10	
F11	11	1,5,7,11,13,14,15	11	F11
F12	8,10,12	5,7,12,13	12	
F13	1,8,10,11,12,13,14	13	13	
F14	8,10,11,14	13,14,15	14	
F15	8,10,11,14,15	15	15	
Round 3				
	R	A	T	Level 2
F1	1,10	1,13	1	
F2	2,10	2,7	2	
F5	5,10,12	5	5	F5
F7	2,7,10,12	7	7	F7
F10	10	1,2,5,7,10,12,13,14,15	10	
F12	10,12	5,7,12,13	12	
F13	1,10,12,13,14	13	13	F13
F14	10,14	13,14,15	14	
F15	10,14,15	15	15	F15
Round 4				
	R	A	T	Level 4
F1	1,10	1	1	
F2	2,10	2	2	
F10	10	1,2,10,12,14	10	F10
F12	10,12	12	12	
F14	10,14	14	14	
Round 5				
	R	A	T	Level 3
F1	1	1	1	F1
F2	2	2	2	F2
F12	12	12	12	F12
F14	14	14	14	F14

Acknowledgements This work is supported by the National Natural Science Foundation of China (Grant No. 72174150) and "the Fundamental Research Funds for the Central Universities" (Grant No. 2020SK018).

Declarations

Conflict of interest The authors have no conflict of interest to declare.

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Yiwei Gong is a Full Professor at the School of Information Management in Wuhan University. He serves as an editorial board member of Government Information Quarterly and Journal of Theoretical and Applied Electronic Commerce. His research interests include Enterprise Architecture, Digital Transformation, and Business Process Management.

Marijn Janssen is a Full Professor in ICT & Governance at the Information and Communication Technology research group of the Technology, Policy and Management Faculty of Delft University of Technology. His research interests are in the field of orchestration, infrastructures, and open and big data. He is Co-Editor-in-Chief of Government Information Quarterly, conference chair of IFIP EGOV series. He was nominated in 2018 and 2019 by Apolitical as one of the 100 most influential people in the Digital Government worldwide https://apolitical.co/lists/digital-government-world100. More information: www.tbm.tudelft.nl/marijnj.