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How enterprise architecture improves the quality of IT investment decisions

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ABSTRACT

According to literature, enterprise architecture (EA) is supposed to support IT investment decision-making. However, it is not yet clear how EA can do that. The objective of this study is to explore how EA can support IT investment decisions. A quantitative research approach was chosen, in which data were collected from a survey of 142 participants. These data were used to perform a comparative analysis between top and bottom quartile organizations on 1) the EA maturity, 2) the use of EA artifacts in the preparation of IT investments, and 3) the key insights that EA provides in preparation of IT investments. We found that top quartile organizations are more mature in all EA maturity areas. They also make more extensive use of different types of EA artifacts in the preparation of IT investment decisions, especially diagnostic and actionable artifacts. Finally, EA provides top quartile organizations with more key insights in the preparation of IT investment decisions, and in particular, strategic insights. As a result of our research we created a conceptual model that integrates seven propositions. Further research is required to test these propositions and develop instruments to aid enterprise architects to effectively support IT investment decisions.

1. Introduction

Enterprise architecture (EA) gained a lot of attention over the years and is employed by many organizations to deal with the increasing complexity of their corporate IT environments (Aier, 2014; Weiss et al., 2013). EA is defined as a discipline that is able to create "overview and insights needed to translate strategy into execution, enabling senior management to take ownership of the key decisions on the design of the future enterprise" (Greefhorst and Proper, 2011). One of these decisions is the IT investment decision. The IT investment decision "selects and funds initiatives and addresses how much to spend, what to spend it on, and how to reconcile the concerns of different stakeholders" (Weill and Ross, 2004). The promise of EA is that it guides and informs IT investment decisions (Blosch and Burton 2014; Gøtze, 2013; Buchanan and Soley, 2002; CIO Council, 2012). In other words, the use of EA would increase the quality of IT investment decisions.

The quality of the outcome of an IT investment decision is an important indicator given the amounts of money that are invested in IT. The estimated IT spending for 2018 is USD 3.68 trillion (Lovelock et al., 2017). According to IDC (2018), the total IT spending by small and medium-sized businesses is forecasted to be nearly USD 602 billion in 2018, an increase of 4.9% over 2017. According to Weill and Ross (2004), "the IT investment decision is one of the five interrelated IT decisions that every enterprise must address, and often the most visible and controversial as some projects will be approved, others are bounced". The CHAOS report indicates that in 2015 only 29% of projects were successful, i.e., on time, on budget, and with a satisfactory result, 19% of all projects failed and 52% were challenged (Standish Group, 2015). IT investment decisions appear to be important as well as risky decisions.

In this research we studied three aspects of EA that relate to how it supports the quality of IT investments. First, the maturity of an EA practice. We consider an EA practice "the whole of activities, responsibilities and actors involved in the development and application of EA" (Van Steenbergen et al., 2010). The maturity of

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an EA practice is an indicator for the quality of an EA practice. The purpose of maturing an EA practice is to increase its performance and effectiveness upon achieving a higher maturity (Meyer et al., 2011). In this research we want to explore whether there is a relationship between the maturity of an EA practice and the quality of IT investment decision outcomes.

Second, the artifacts created by EA practices. We consider an EA artifact as a single document describing a particular aspect of EA (Kotusev et al., 2015). In this research we are particularly interested in what EA artifacts are used in the preparation of IT investment decisions. Third, the key insights that EA provides in the preparation of IT investment decisions. These insights should enable senior management to take ownership of the key decisions on the design of the future organization (Greefhorst and Proper, 2011; Johnson et al., 2004; Janssen, 2012; Op 't Land et al., 2008).

In this study, we want to explore how EA delivers value to IT investment decisions. In this way, we seek to complement and extend existing studies on EA benefits and success factors by building theory on how EA contributes to IT investment decisions. Therefore, our main research question is:

How does EA improve the quality of IT investment decisions?

To answer this question, a quantitative approach was followed. Based on a survey among 142 EA developers, EA users and EA implementers, we performed a comparative analysis of two groups, i.e., the top and bottom quartile cases with regard to the quality of the outcomes of the IT investment decisions. For both the top and bottom quartile cases, we measured the EA maturity, the use of EA artifacts in the preparation of IT investment decisions and, finally, the key insights that EA provides in the preparation of IT investment decisions. Based on the differences between top and bottom quartile cases, we generated theory.

This study demonstrates that top quartile organizations have a more mature EA practice across the board. Furthermore, in top quartile organizations more diagnostic and actionable EA artifacts are used and, as a likely consequence, EA provides more strategic insights in the preparation of IT investment decisions, like whether the IT investment fits with business strategy and the relationships with past and future investments.

This research is important because it underpins the value of EA in supporting IT investment decisions. Enterprise architects are provided with useful insights about where to focus on to improve their practices, processes and products. For decision-makers, this research demonstrates which artifacts and insights they need to ask their enterprise architects when preparing IT investment decisions. Researchers are provided with frameworks to measure the contribution of EA and the outcomes of IT investment decisions, as well as with insights for further researching the benefits of EA with regard to IT investment decisions.

In an earlier paper based on the same data, we reported on a quantitative study about the relationship between EA maturity and the quality of IT investment decisions (Van den Berg et al., 2018). To make this particular paper self-contained we reused some parts of the earlier paper. In particular, we have reused the subsections on theoretical background of the quality of IT investment decision outcomes (2.1.) and EA maturity (2.2.2.). We also reused the subsections on measurement of the quality of IT investment decision outcomes (3.2.1.1.) and EA maturity (3.2.1.2.) as well as the subsections on data collection (3.2.2.), focus groups (3.2.3.), and data reliability and validity (3.2.4.).

The theoretical background of this research is presented in the next section. In the subsequent section, we discuss the research model and methodology. The section after that contains the quartiles and descriptives. In the next section we present the results of our research. Finally, we discuss the results, outline the implications of this research, elaborate on the limitations, and end with a conclusion.

2. Theoretical background

In this section we discuss related work on the quality of IT investment decision outcomes, and the use of EA. With regard to the quality of IT investment decision outcomes we searched Google Scholar for literature with the keywords "quality of a decision" and "success of a decision" followed by forward and backward snowballing. Google Scholar was also used to find relevant literature on "enterprise architecture maturity" followed by forward and backward snowballing. Based on our extensive experience as practicing enterprise architects and EA researchers, we created a list of EA artifacts and key insights. In Google Scholar references were searched for each of the EA artifacts and key insights.

2.1. Quality of IT investment decision outcomes

The purpose of this research is to compare the use of EA between organizations with high quality outcomes of IT investment decisions and organizations with low quality outcomes of IT investment decisions. In this subsection we discuss related work with regard to the components that comprise the quality of the outcomes of an IT investment decision: a decision, the quality of a decision, and an IT investment decision.

We consider a decision "a specific commitment to action" (Mintzberg et al., 1976). A decision is made in a process that follows two stages, the first of which is the formulation of the decision, in which the decision is prepared and ends with the specific commitment to action. In the second stage the decision is implemented (Papadakis et al., 2010). Fig. 1 shows the two stages.

There are differing perspectives about the quality of a decision. These perspectives can be related to the different stages of the decision-making process. One perspective is that rational analysis during the formulation phase improves the initial quality of the decision: "in high velocity environments, the more comprehensive the search for strategic alternatives, the better the performance of the firm" (Bourgeois and Eisenhardt, 1988). The quality of a decision thus depends on the formulation stage. Another perspective is that successful decisions were found "to be more on time, have lived up to intentions more than others, and [are] more satisfactory to those concerned" (Miller, 1997). In this perspective, the quality of a decision highly depends on the implementation. Miller (1997) regards a decision as being successful when it is completed, achieved, and acceptable. While the decision itself is established at the end of the formulation stage, its completion, achievement, and acceptability can only be measured after the implementation. Hetebrij (2011) argues that the quality of a decision depends on two factors: decision power and content quality. A decision has decision power if it is made on a timely basis and if it is actually implemented. A decision has content quality if it is based on relevant knowledge and if the concerns of the stakeholders involved are carefully considered. Hetebrij (2011) relates the success of a decision to both its formulation and implementation. Nooraie (2008) also states that the decision outcomes may

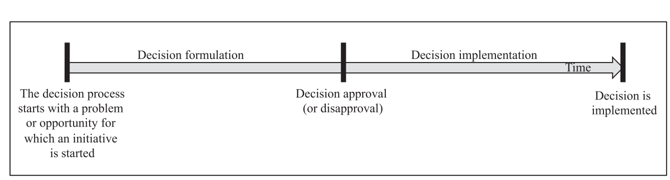

Fig. 1. Stages of decision-making (based on Papadakis et al., 2010).

be investigated in two stages. In the formulation stage “the quality of the decision-making process output in terms of timeliness or speed of the decision-making, acceptability to interested units and people, and adaptiveness to change can be evaluated. This actually defines how well the decision process is carried out”. The implementation stage determines “how well the decision (selected alternative) is accomplished, the decision goals are achieved, or problems are solved” (Nooraie, 2008). The results of both the formulation and implementation stage determine the quality of a decision.

The IT investment decision is the decision to approve or disapprove an IT investment. Compared with other types of decisions, IT investment decisions have some specific characteristics. First, IT investments require funds or budgets. Budgets are amounts of money required for the investment. As part of the IT investment decision, a budget should be approved. Second, IT investment decisions cannot be taken in isolation; other IT investment decisions must be taken into account when making a particular IT investment decision. Organizations try to achieve an optimal IT investment portfolio, i.e., a portfolio in which all investments contribute to strategic, long-term objectives. Strategic alignment between business strategy and IS strategy positively moderates the relationship between IT investments and firm performance (Byrd et al., 2006). We consider an IT investment decision to follow the two stages of decision-making: the formulation and the implementation stage. The results of both stages determine the quality of IT investment decisions.

2.2. Use of EA

2.2.1. EA positioning

The use of EA differs across organizations and EA can have different meanings for both practitioners and researchers. Lapalme (2012) introduced the three schools of EA based on a review of the key EA literature. He makes the distinction between enterprise IT architecting, enterprise integrating, and enterprise ecological adaptation. Each school is grounded in its own belief system. In enterprise IT architecting, EA is the glue between business and IT, in enterprise integrating, EA is the link between strategy and execution, in enterprise ecological adaptation, EA is the means for organizational innovation and sustainability. In this research we used Greefhorst and Proper’s definition of EA: “EA as a discipline that is able to create overview and insights needed to translate strategy into execution, enabling senior management to take ownership of the key decisions on the design of the future enterprise” (Greefhorst and Proper, 2011). Like in Lapalme’s enterprise integrating school we consider EA as the link between strategy and execution. However, we did not include the schools of thought in our research.

Based on an exploratory empirical analysis, Aier et al. (2008) distinguished three different EA scenarios. These scenarios depend on the level of organizational penetration of EA and the adoption of advanced architectural design paradigms and modeling capabilities. The most mature EA scenario is “EA engineer” which scores high on both dimensions. The scenario “IT architect” scores low on both dimensions. The scenario “EA initiator” scores high on the level of organizational penetration but low on the adoption of advanced architectural design paradigms and modeling capabilities. The results of Aier’s analysis demonstrate that there is no overall approach to implement EA in practice. We regard the differences between Aier’s scenarios as a matter of maturity, the subject we will discuss next and is part of our study.

2.2.2. EA maturity

To aid organizations in the adoption of EA best practices, maturity models have been developed and proposed. These models offer assessment frameworks and roadmaps for increasing EA maturity (Vallerand et al., 2017). Several EA maturity models exist, with different purposes and different ways of measuring the EA maturity (Meyer et al., 2011; Vallerand et al., 2017; Van Steenbergen et al. 2007). We choose to apply the Dynamic Architecture Maturity Matrix (DyAMM) in this study. The DyAMM is developed by Sogeti and scientifically evaluated (Van Steenbergen et al., 2007; Van Steenbergen et al., 2010; Van Steenbergen et al., 2012). DyAMM is an instrument to incrementally build an architecture function. It distinguishes 17 architecture practice focus areas that must be implemented. These focus areas were derived from practical experience in the field of EA. Each focus area is divided into a number of maturity levels. By positioning these maturity levels against each other in a matrix, the DyAMM presents the order in which the different aspects of the architectural function should be implemented. A total number of 137 checkpoints (statements) have to be answered with a “yes” or “no” to determine the maturity of a particular EA practice. If an organization does not satisfy all checkpoints of a certain maturity level, DyAMM provides improvement suggestions. DyAMM is based on the DyA EA approach developed by Sogeti. This approach focuses on a goal-oriented, evolutionary development of the architectural function (Wagter et al., 2005). We choose DyAMM because it is a model that can be used to assess the maturity of an EA practice, the latest version is published recently (in 2012), the model is publicly available, and has been applied across different industries (Van Steenbergen et al., 2010).

2.2.3. EA artifacts

EA practices create different types of artifacts. In this research we distinguish between different types of EA artifacts as can be seen in Table 1. We are aware of different concepts and definitions with regard to EA. There is not one common vocabulary or set of standardized artifacts in the EA community despite efforts of the Open Group (2018) and Kotusev (2018).

2.2.4. EA insights

Table 2 contains the key insights that EA possibly can provide in the preparation of IT investment decisions, and thus help to improve these decisions. These insights are derived from literature.

3. Research design

3.1. Research questions

One of the 2012 Clinger-Cohen Core Competencies & Learning Objectives (11.4) states that “the use of EA in IT investment decision-making should be one of the competencies of EA” (CIO Council, 2012). There is broad consensus that the EA discipline should guide and inform IT investment decisions (Blosch and Burton, 2014; Gøtze, 2013; Jusuf and Kurnia, 2017; Buchanan and Soley, 2002). However, there is little evidence on the how. With this research, we aim to explore how to apply EA to achieve higher quality outcomes of IT investment decisions. In particular, we are interested in what EA maturity areas, what EA artifacts and what key insights from EA contribute to more successful IT investments. This leads to the following questions:

Q1: What is the maturity on EA focus areas in organizations with high-quality IT investment decision outcomes compared to organizations with low-quality IT investment decision outcomes?

Q2: What EA artifacts are used in the preparation of IT investment decisions in organizations with high-quality IT investment decision outcomes compared to organizations with low-quality IT investment decision outcomes?

Table 1
EA artifacts that can be used in the preparation of IT investment decisions.

Type of EA artifact	Definition	References
Business capability models	Structured graphical representation of all organizational business capabilities, their relationship and hierarchy. A business capability is a particular ability that a business may possess or exchange to achieve a specific purpose.	Kotusev (2018) Open Group (2018)
Future state architectures	High-level graphical descriptions of the desired long-term future state of an organization. Sometimes referred to as the "to-be", "soll" or "target" architecture.	Kotusev (2018) Van der Raadt and Van Vliet (2008) Open Group (2018)
Current state architectures	Descriptions of the current situation of an organization. Sometimes referred to as the "as-is" or "ist" architecture.	Van der Raadt and Van Vliet (2008)
Principles	A declarative statement that normatively prescribes a property of the design of an artifact.	Greefhorst and Proper (2011) Kotusev (2018)
Policies	Overarching organizational norms typically of restrictive nature providing compulsory prescriptions in certain areas.	Kotusev (2018)
Guidelines	Prescriptions of best practices that provide guidance on the optimal ways to carry out design or implementation activities.	Kotusev (2018) Open Group (2018) Van der Raadt and Van Vliet (2008)
Standards	Three classes of standards exist: 1) Legal and regulatory obligations: these standards are mandated by law and therefore an enterprise must comply or face serious consequences. 2) Industry standards: these standards are established by industry bodies and are then selected by the enterprise for adoption. 3) Organizational standards: these standards are set within the organization and are based on business aspiration. The purpose of standards is to help achieve technical consistency, technological homogeneity and regulatory compliance.	Open Group (2018) Kotusev (2018)
Heat maps	A map where different colors are used to visualize the status of certain attributes of a business capability. These attributes may include maturity, effectiveness, performance, and the value or cost of each capability to the business. Heat maps can also be used in conjunction with e.g., information objects.	Open Group (2018) Roelens and Poels (2014)
Landscape diagrams	High-level connections between various applications, databases, platforms, systems and sometimes business processes covering large parts of the corporate IT landscape, typically in their current states.	Kotusev (2017)
Roadmaps	An abstracted plan for business or technology change, typically operating across multiple disciplines over multiple years. A roadmap describes a realization path from the current state to the future state.	Open Group (2018) Van der Raadt and Van Vliet (2008)
Project start architectures	Delineates a concrete and usable framework within which a project should be carried out. It contains the translation of general principles and policy directives into specific project guidelines. It provides the constraints and general direction for the further elaboration of the project's fundamental design.	Wagter et al. (2005) Foorthuis and Brinkkemper (2007)
Solution outlines	High-level description of specific proposed solutions.	Kotusev (2018)

Table 2
Insights that EA may provide in the preparation of IT investment decisions.

Type of EA insight	Description	References
Relationship with past IT investments	IT investments can benefit from previous IT investments.	Riempp and Gieffers-Ankel (2007)
Relationship with current IT investments	IT investments can interfere with current IT investments, positively or negatively.	Riempp and Gieffers-Ankel (2007) Van den Berg and Van Vliet (2016) Niemi and Pekkola (2016)
Relationship with future IT investments	IT investments can create opportunities for future IT investments.	Riempp and Gieffers-Ankel (2007)
Risks of IT investment	IT investments are inherently risky due to uncertainty about their economic impact, technological complexity, rapid obsolescence, implementation challenges and so on. IT risk is the variability of returns on IT investment, which is increased by unexpected positive or negative outcomes.	Riempp and Gieffers-Ankel (2007) Jusuf and Kurnia (2017) Plessius et al. (2014) Tamm et al. (2011) Dewan et al. (2007)
Feasibility of IT investment	IT investments have a certain degree of feasibility, i.e., the ability and likelihood to successfully complete an IT investment including relevant factors such as economic, technological, legal and scheduling factors.	Standish Group (2015) Investopia (2018)
Fit with the future state architecture	IT investments can contribute to the realization of the future state architecture.	Buchanan and Soley (2002)
Fit with the business strategy	IT investments can contribute to the realization of the business strategy.	Buchanan and Soley (2002) Tamm et al. (2011) Niemi and Pekkola (2016)
Consequences for the current state	IT investments can have consequences for the current state of operations, clients and markets.	Plessius et al. (2014)
Options for the future	IT investments can create options for the future, i.e., an IT investment now can create an opportunity to gain future benefits.	Saha (2006) Slot (2010)
Different solution alternatives and their pros and cons	IT investments can be realized by means of different solution alternatives. These alternatives have their pros and cons.	Plessius et al. (2014)

Table 3
Measurement items for OQ with factor loadings.

	Measurement item	λ
OQ1	The desired outcomes of IT investments are achieved in my organization	0.75
OQ2	Stakeholders are satisfied with the final outcomes of IT investments in my organization	0.69
OQ3	The final outcomes of IT investments contribute to strategic, long-term objectives in my organization	0.59
OQ4	The due dates for IT investments are achieved in my organization	0.69
OQ5	IT investments in my organization are implemented on a timely basis	0.72
OQ6	IT investments in my organization are on budget	0.75

Q3: What are the key insights that EA provides in the preparation of IT investment decisions in organizations with high quality IT investment decision outcomes compared to organizations with low quality IT investment decision outcomes?

3.2. Research methodology

We followed a quantitative approach with the aim to build theory. We collected data by means of a survey among EA developers, EA users, and EA implementers. The purpose of the survey was twofold. Firstly, to measure the quality of IT investment decision outcomes and the EA maturity. Secondly, to gain insight in the use of EA artifacts and the key insights that EA provides in the preparation of IT investment decisions. These insights “can help identify the concepts, are the basis for measurement, and are very appropriate for early stages of the research” (Malhotra and Grover, 1998). In addition to the survey, we collected explanations for our findings with three focus groups.

3.2.1. Measurement model

To answer the research questions, we took the top and bottom quartile cases based on the quality of IT investment decision outcomes and compared the way organizations in these quartiles make use of EA. To determine the quality of IT investment decision outcomes (OQ) and the division of cases over quartiles we asked six questions in the questionnaire. To answer research question Q1 we had to measure the EA maturity (EAM) on different aspects. The survey contains 23 questions on EAM. Finally, we used two questions to determine the use of EA artifacts (Q2) and the key insights that EA provides (Q3). Next to the aforementioned questions, the survey contains general questions on EA and IT investments and on demographics. In the next subsections, we explain the measurement of OQ, EAM, use of EA artifacts, and key insights that EA provides in more detail.

3.2.1.1. Measurement OQ. OQ is measured in a formative mode by six indicators. The measurement items for OQ are based on a combination of decision-making literature and IT investment literature (Miller, 1997; Miller et al., 2004; Hetebrij, 2011; Nooraie, 2008; Weill and Ross, 2004; Byrd et al., 2006; Ward et al., 2008). These items are measured on a five-point Likert scale (1 = never, 2 = seldom, 3 = about half the time, 4 = often, 5 = always). Table 3 provides an overview of the measurement items for OQ. The median of each of these items is 3.00.

The overall OQ has a mean $\mu = 3.09$ with standard deviation $\sigma = 0.621$.

3.2.1.2. Measurement EAM. The measurement model for EAM is based on DyAMM (Van Steenbergen et al., 2007; Van Steenbergen et al., 2012). The way we applied DyAMM in this research is different from its regular application. First, DyAMM is primarily an instrument to incrementally build an architecture function. In this study we will only apply the measurement part of DyAMM. Second, the total number of checkpoints or indicators of DyAMM is 137. We regard this number of measurement items as too large to handle in a survey. Instead of asking whether these 137 indicators have been achieved, we created statements that describe the different maturity levels per focus area. Since the initial level is not described in DyAMM, we added statements for this level for each of the focus areas.

DyAMM measures the maturity of an EA practice in 17 focus areas. Accordingly, the measurement model for EAM consists of 17 construct dimensions (focus areas). Each dimension is measured on a maturity level ranging from 0 to A, B, C or D. Table 4 illustrates that fifteen dimensions have four levels, one dimension has three levels and one dimension five. For 12 construct dimensions we asked one question containing statements for each maturity level. For *development of architecture* we divided the statements over three questions. For *alignment with realization, implementation of the architectural role, interaction and collaboration*, and *architectural tools* we divided the statements over two questions. In total we asked 23 questions to determine the maturity level per construct dimension. Each question contains two to four statements.

The way we measure EAM is the same as the measurement of maturity in DyAMM, which is based on a step-by-step approach. The first step toward EA maturity starts by reaching level A in three areas: *development of architecture, alignment with business strategy*, and *commitment and motivation*. Once a start has been made on these areas, then focus on obtaining level A in the *use of architecture, alignment with realization*, and *interaction and collaboration*. In effect, the levels for all 17 construct dimensions can be comparatively ranked in a similar manner. The resulting set of interdependencies is represented by Table 5 (Van Steenbergen et al., 2012).

The letters in Table 5 (0, A, B, C or D) indicate the level of maturity per construct dimension (row in the matrix). Each construct dimension has its own maturity. However, the overall EA maturity (EAM), indicated by the columns in Table 5, depends on the maturity achieved for each of the construct dimensions taking into account the dependencies between the construct dimensions. Based on 23 questions we first determined the maturity level per construct dimension. As a second step, EAM is determined based on the dependencies between the construct dimensions. Table 6 contains an example to demonstrate the measurement of EAM. Each of the construct dimensions in Table 6 has achieved a certain level of maturity, indicated by the gray colors. For example, *development of architecture* is at level B. EAM is determined by looking at the first column where a letter is not colored gray. This is the “A” in column 2 for *interaction and collaboration*, which indicates that this construct dimension has not yet reached maturity level A. This means that in this example column 1 has been achieved, so EAM is 1.

To summarize, EAM is measured according to the scales of maturity and varies from 0 to 12 with equal distances between the scales.

3.2.1.3. Measurement of use of EA artifacts and key insights that EA provides. We used two questions to determine what EA artifacts are used respectively what key insights EA provides in the preparation of IT investment decisions. Respondents could choose from a predefined list that was composed based on Tables 1 and 2, with

Table 4
Measurement model for EAM.

Construct dimension	Level 0	Level A	Level B	Level C	Level D
Development of architecture	Initial	Architecture is developed with a clear focus on objectives	Architecture is developed in consultation with the stakeholders	Architectures are developed as a cohesive whole	–
Use of architecture	Initial	Architecture is informative	Architecture is prescriptive	Architecture is aligned with the decision-making process	–
Alignment with business strategy	Initial	Architecture is related to business objectives	Architectural process is steered by the business objectives	Architecture is an integral part of the strategic dialogue	–
Alignment with realization	Initial	Ad hoc	Structural	Interactive	–
Relationship to the as-is state	Initial	Attention to the as-is state	Future and existing situations are viewed in connection	–	–
Responsibilities and authorities	Initial	Responsibility for architecture as a product has been assigned	Management is responsible for the architectural process	Senior management is responsible for the effect of architecture	–
Alignment with change portfolio	Initial	Steering the content of individual projects	Coordination between projects	Strategic portfolio management	–
Monitoring	Initial	Reactive monitoring	Proactive monitoring	Fully incorporated monitoring	–
Quality assurance	Initial	Explicit quality review	Quality assurance process has been set up	Fully incorporated quality assurance policy	–
Management of the architectural process	Initial	Management is incidentally executed	Management procedures have been set up	Continuous process improvement	–
Management of the architectural products	Initial	Management is incidentally executed	Management procedures have been set up	Presence of a management policy	–
Commitment and motivation	Initial	Allocation of budget and time	Architecture is acknowledged as a management instrument	Architecture is acknowledged as a strategic issue	–
Implementation of the architectural role	Initial	Role has been recognized	Role has been detailed	Role is supported	Role is appreciated
Architectural method	Initial	Ad hoc	Structural	Fully incorporated	–
Interaction and collaboration	Initial	Collaboration between architects	Involvement of the stakeholders	Shared ownership	–
Architectural tools	Initial	Ad hoc and product-oriented	Structural and process-oriented	Integration of tools	–
Budgeting and planning	Initial	Ad hoc	Structural	Optimizing	–

Table 5
Measurement model for EAM, with maturity levels per construct dimension and columns with maturity scales.

Construct dimension	0	1	2	3	4	5	6	7	8	9	10	11	12
Development of architecture		A			B			C					
Use of architecture			A			B				C			
Alignment with business strategy		A			B					C			
Alignment with realization			A				B			C			
Relationship to the As-Is state					A				B				
Responsibilities and authorities				A		B					C		
Alignment with change portfolio				A				B		C			
Monitoring				A		B		C					
Quality assurance								A		B		C	
Management of the architectural process							A		B		C		
Management of the architectural products					A			B					C
Commitment and motivation		A					B		C				
Implementation of the architectural role				A		B		C				D	
Architectural method				A					B			C	
Interaction and collaboration			A		B				C				
Architectural tools							A				B		C
Budgeting and planning					A						B		C

common EA artifacts and key insights. Multiple answers were allowed.

3.2.2. Data collection

Data were collected by means of a questionnaire. The target population of the survey is defined as 'all people working in commercial or public organizations (either as internal employees or external consultants) who in a professional capacity have to deal with EA as an EA developer, EA user or EA implementer'. The unit of analysis is the individual worker, who is asked about his or her perceptions on the maturity of the EA practice and the quality of IT investment decision outcomes. We followed the principles of survey research from Kitchenham and Pfleeger (2002a,b,c,d, 2003).

The development of the survey underwent several iterations. Originally, the survey was developed by the first author of this

Table 6
Example how to determine the overall EA maturity.

Construct dimension	0	1	2	3	4	5	6	7	8	9	10	11	12
Development of architecture		A			B			C					
Use of architecture			A			B				C			
Alignment with business strategy		A			B					C			
Alignment with realization			A				B			C			
Relationship to the As-Is state					A				B				
Responsibilities and authorities				A		B					C		
Alignment with change portfolio				A				B		C			
Monitoring				A		B		C					
Quality assurance								A		B		C	
Management of the architectural process							A		B		C		
Management of the architectural products					A			B					C
Commitment and motivation		A					B		C				
Implementation of the architectural role				A		B		C				D	
Architectural method				A					B			C	
Interaction and collaboration			A		B				C				
Architectural tools							A				B		C
Budgeting and planning					A						B		C

article and improved in several iterations with the other authors. Then a web version of the survey was created which was tested for reliability and validity in two iterations. In a first iteration, the survey was tested by 13 experienced EA developers, EA users and EA implementers. Six of them provided feedback by email. Seven participants were asked to think aloud when answering the questions in the presence of one of the researchers who took notes. The participants were asked to fill in the survey and provide feedback on a) the clarity of the questions: identify missing or unnecessary questions, ambiguous questions, and instructions, b) the questions that could not be answered due to a lack of knowledge, or because one could not remember anymore, c) how much time it took to complete the survey, and d) any suggestions for improvement. Based on the feedback the survey and instructions were improved for clarity, consistency, and comparison reasons. The most important improvement was to adjust questions on EA maturity. Originally, we had one question per focus area containing three to five statements per maturity level depending on the number of maturity levels per focus area. Based on the feedback of participants we divided some questions into two or even three questions because some statements were ambiguous; they included different topics in one statement. Because of this rather fundamental adjustment we conducted a second test with two participants. These participants were also asked to think aloud. The results of this test led to some small adjustments.

A special issue that we had to overcome was the timeframe. According to Kitchenham and Pfleeger (2002b), you may get inaccurate responses if you ask people about events that happened long in the past. In our case we had to ask questions about completed IT investment decisions. For larger IT investment decisions, it can take years to complete the implementation. What can participants remember from these decisions and how accurate will the answers be? As a first measure we did not ask about the quality of a particular decision, but about the quality of the decisions that were implemented recently. Secondly, we asked the test participants how confident they were about their answers on the questions on EA maturity as well as on IT investment decisions. Overall, they acknowledged that they were confident.

The final questionnaire contained 54 questions and was created in SurveyMonkey. At any moment during the survey session, respondents could see what percentage of the questions they had responded to, encouraging them to complete it. Furthermore, we offered participants the possibility to provide their email address if they wanted to receive the results of the survey.

Our survey is unsupervised; i.e., the target group was invited by email to fill in a questionnaire that was sent as a link to a survey tool (Pfleeger and Kitchenham, 2001). All survey questions explicitly referred to the current (or latest) organization in which the respondents worked, for example because they were an employee or because they were employed there as an external consultant. The terms “Enterprise Architecture” and “IT investment decision” were defined at the beginning of the questionnaire. In the remainder of the questionnaire several other terms were explained. We applied different exclusion criteria. At first, we excluded submissions that were not completed. Secondly, we excluded submissions in which respondents answered that they did not deal with EA. Finally, submissions were excluded that contained inconsistent answers.

Due to the lack of registers with EA developers, EA users or EA implementers, we used a non-probability sample, i.e., a sample that has not been selected using a random selection method. As a consequence, some units are more likely to be selected than others (Bryman and Bell, 2015). When targeting EA developers, EA users and EA implementers, we lowered the risk of not being selected by using some well-known networks to distribute our survey. We concentrated most of our efforts on the Netherlands. We used the following Dutch networks: NAF (Dutch architecture forum), CIO-platform (Dutch CIO organization), KNVI (Dutch computer society), LAC (annual Dutch architecture conference), and the network of one of the architectural thought leaders in the Netherlands. These networks attracted the attention of their members to the survey by newsletters or dedicated emails. Since the survey was drafted in English it was also advertised on social media. Some international thought leaders on EA forwarded the link to the survey to their networks. Furthermore, some international networks distributed the survey: an international IT service provider and IFIP. The data were collected between June 2017 and August 2017.

In total 260 respondents started the survey of which 173 completed it. After applying the exclusion criteria 142 surveys remained. In the end we had 142 cases at our disposal. As the survey was distributed to unconfined users, an immediate response rate cannot be calculated. Therefore, we conducted a power analysis using G*Power 3 software (Faul et al., 2007). Given our research model, and with type-1 error probabilities set to $\alpha < 0.05$, a sample size of $N = 123$ was required to reach sufficient statistical power ($1 - \beta$ error probability > 0.80) for effect sizes of

$f^2 > 0.15$ (medium) (Cohen, 1988). This implicates that our sample size ($N = 142$) is adequate.

3.2.3. Focus groups

"We discussed the results of the survey in three focus groups. The focus groups were used as an ex post method to aid in interpreting the survey results (Sutton and Arnold, 2013). The members of the focus groups were experienced EA developers, EA users and EA implementers, with an average of 20 years' experience with EA. The first group consisted of two EA consultants and one CIO. The second group had one EA consultant, three enterprise architects, one information manager, two managers of CIO offices and one project manager, all from different organizations. The last focus group had eight members from the same organization, two of them acting as IT manager, two as information manager, two as enterprise architect, one as information analyst, and one as information security coordinator. A standard procedure was used to achieve a high level of comparability across groups (Morgan, 1996). In order to stimulate independent thinking, we asked the focus group members to individually brainstorm and write down their explanations before discussing these in the group (Sutton and Arnold, 2013). The focus group meetings lasted about two hours and were recorded and transcribed.

3.2.4. Validity and reliability

We evaluated our theoretical model in terms of content validity, face validity, construct reliability, indicator reliability, and data normality.

Content validity was ensured upfront by using existing models and literature to create the theoretical model and develop the constructs. As explained before, the content validity and face validity were also tested by 15 experienced EA developers, EA users, and EA implementers; all members of the target population of our survey. Based on their comments, we adjusted the survey to ensure that it includes everything it should and nothing that it should not (Kitchenham and Pfleeger, 2002c).

Regarding construct reliability we used Cronbach's Alpha to test the internal consistency of our constructs (Kitchenham and Pfleeger, 2002c). The Cronbach's Alpha for OQ is 0.86. The desirable values of Cronbach's Alpha are in the magnitude of 0.7 or 0.8 (Field, 2009). The Cronbach's Alpha value for OQ exceeds 0.8, which confirms the reliability of this construct.

Indicator reliability was tested by means of factor loadings. Table 3 demonstrates that OQ has five or more strongly loading items ($\lambda = 0.50$ or better). This indicates that OQ is a solid factor (Costello and Osborne, 2005).

As another test, we assessed the data for normality by using a sample moment test of skewness and kurtosis statistics. This analysis confirmed that relevant thresholds (skewness < 2 and kurtosis < 7) were not exceeded (Stevens, 2012).

4. Quartiles and descriptives

4.1. Quartiles

Initially, the quartiles of OQ of the 142 cases were determined with SPSS, a software package for statistical analysis. The first quartile value is 2.67, the second one is 3.17, and the third quartile value is 3.50. Based on these quartile values we determined the top and bottom quartiles. The boxplot of SPSS in Fig. 2 demonstrates the distribution of the OQ scores. The upper and lower limits of the box represent the first and third quartiles of the OQ. The median is represented by the horizontal bar in the middle of the box.

As can be seen in the frequency distribution of OQ in Table 7, the first quartile value (2.67) and the third quartile value (3.50) contain 12 cases. As a consequence, it is impossible to have an exact equal proportion of cases in all four quartiles. We therefore consider all cases with an OQ < 2.67 as bottom quartile cases and the cases with OQ > 3.50 as top quartile cases. We consider all remaining cases as the interquartile range. Table 8 shows the number of cases as well as statistics for the different quartiles.

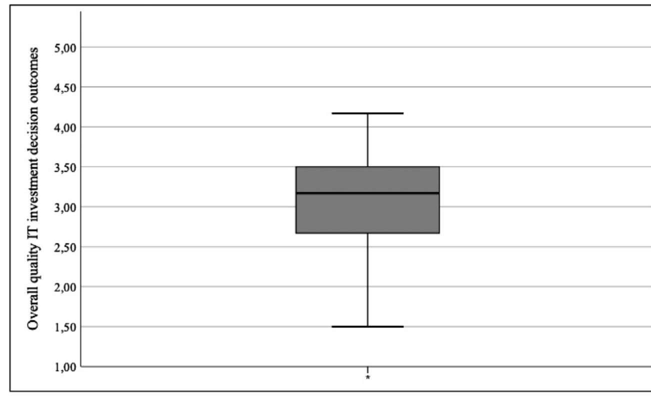

Fig. 2. Boxplot of quality of IT investment decision outcomes.

4.2. Descriptives

Tables 9 and 10 demonstrate the division of the 142 respondents to the survey over the top quartile (top performer) and bottom quartile (bottom performer) groups. The respondents can have multiple roles regarding EA: developer, user and/or implementer of EA. From Table 9 we conclude that respondents with regard to their EA role are equally represented in the top and bottom quartile group.

Respondents can also have different roles with regard to IT investment decisions: accountable, responsible, consulted and/or informed on IT investment decisions. From Table 10 we learn that in the top quartile group, respondents who are responsible for IT investment decisions are more represented, and respondents who are consulted and informed about IT investment decisions are less represented compared to the bottom quartile group.

Fig. 3 contains the distribution of respondents over economic sector per quartile. This figure demonstrates that top quartile cases are proportionally more represented in the information, communication, entertainment and recreation sector where bottom quartile cases are more represented in the public administration sector. The public administration sector contains relatively more bottom and

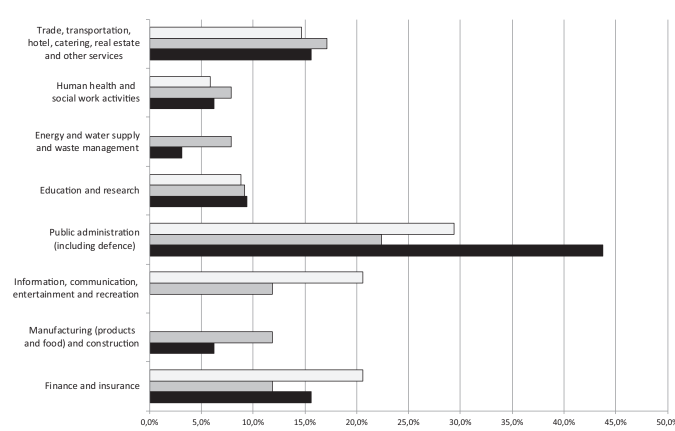

Fig. 3. Distribution respondents over economic sector per quartile.

Table 7
Frequency distribution of quality of IT investment decision outcomes.

OQ	Frequency	Percentage	Cumulative percentage
1.50	1	0.7	0.7
1.83	1	0.7	1.4
2.00	7	4.9	6.3
2.17	8	5.6	12
2.33	6	4.2	16.2
2.50	9	6.3	22.5
2.67	12	8.5	31
2.83	13	9.2	40.1
3.00	13	9.2	49.3
3.17	7	4.9	54.2
3.33	19	13.4	67.6
3.50	12	8.5	76,1
3.67	10	7	83,1
3.83	7	4.9	88
4.00	14	9.9	97,9
4.17	3	2.1	100
Total	142	100.0	

Table 8
Descriptives per quartile.

Statistic	Bottom quartile	Inter-quartile	Top quartile
Number of cases	32	76	34
Mean quality IT investment decision outcomes (OQ)	2.22	3.10	3.88
Standard deviation IT investment decision outcomes (OQ)	0.24	0.29	1.67
Mean EA maturity (EAM)	0.53	1.61	2.00
Standard deviation EA maturity (EAM)	0.98	1.88	1.95

Table 9
Distribution respondents over target population (more than one answer possible).

Role with regard to EA	Total sample		Top quartile		Bottom quartile	
	#	%	#	%	#	%
Developer of EA artifacts (e.g. enterprise architect, domain architect, EA-manager, external EA consultant)	123	51.5	27	50.9	30	51.7
User of EA artifacts (e.g. C-level executive, business manager, IT manager, information manager, portfolio manager)	51	21.3	12	22.6	13	22.4
Implementer of EA artefacts (e.g. project manager, solution architect, software architect, business analyst, information analyst, developer)	65	27.2	14	26.4	15	25.9
Total	**239**	**100**	**53**	**100**	**58**	**100**

Table 10
Distribution respondents over target population (more than one answer possible).

Role with regard to IT investment decisions	Total sample		Top quartile		Bottom quartile	
	#	%	#	%	#	%
Accountable (approves IT investment decisions)	13	5.3	3	5.2	3	5.4
Responsible (prepares IT investment decisions)	77	31.6	20	34.5	12	21.4
Consulted (consulted in the preparation of IT investment decisions)	105	43.0	25	43.1	28	50.0
Informed (informed about IT investment decisions)	44	18.0	9	15.5	12	21.4
No role	5	2.1	1	1.7	1	1.8
Total	**244**	**100**	**58**	**100**	**56**	**100**

less top performers compared to the information, communication, entertainment and recreation sector.

Fig. 4 shows the distribution of respondents over organizational size per quartile. The bottom quartile cases are somewhat more represented in the medium-sized organizations (500–5000 employees) and less in the small organizations (<500 employees). According to this study, medium-sized organizations contain relatively fewer top performers and more bottom performers.

62% of all respondents come from the Netherlands. The other 38% are from 21 different countries around the world. The geographical distribution of respondents per quartile is different. In the bottom quartile, 50% of cases are from the Netherlands and the other 50% are from abroad. In the top quartile group 58.8% of cases are from the Netherlands and 42.2% are from other countries.

Fig. 5 presents the distribution of respondents according to the years of experience with EA, again per quartile. The average number of years ago that the EA practice was first established is 5.5 years for the bottom quartile and 9.4 years for the top quartile cases. Organizations with the highest quality of IT investment decision outcomes have a longer tradition in EA than those with the lowest quality of IT investment decision outcomes.

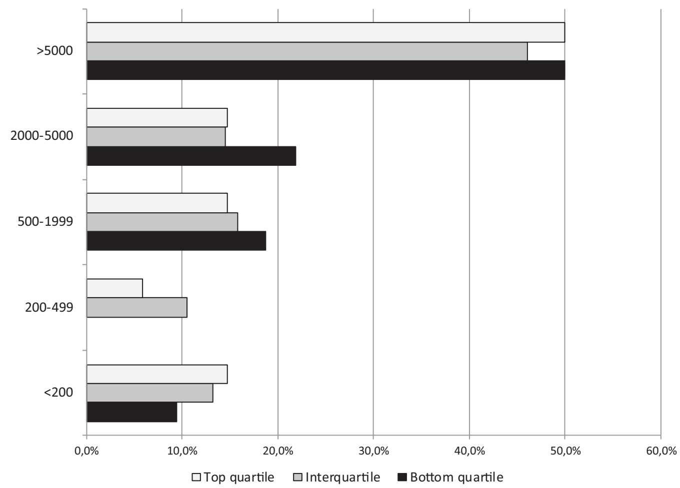

Fig. 4. Distribution respondents over organizational size per quartiles.

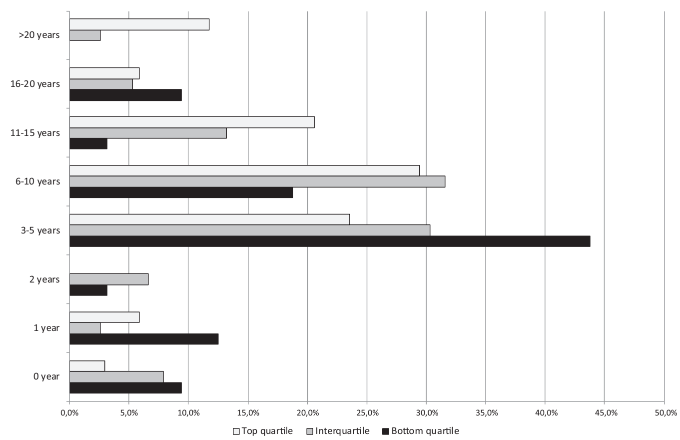

Fig. 5. Distribution of respondents according to number of years EA practice per quartile.

5. Results

In this section we compare the top and bottom quartiles with regard to EA maturity, the use of EA artifacts, and the key insights that EA provide.

5.1. Comparison EA maturity

As part of the survey we measured the EA maturity based on DyAMM. Fig. 6 contains the distribution of the top and bottom quartile cases per EAM scale. As can be seen, more than 70% of the bottom quartile cases are still at EA maturity scale zero. This is only 35% for the top quartile cases.

Fig. 6 illustrates that top quartile cases have an EA practice that is more mature than bottom quartile cases. We conducted an independent sample test (t-test) with EAM as the dependent variable and OQ as the independent variable, to determine whether the difference between the top and bottom quartile group is significant. We checked the data for two assumptions. First, despite the slight deviation from normality we found that the distribution of EAM is normal enough to carry out a t-test. Second, Levene's test of equality of variances shows that the assumption of homogeneity has been violated. Therefore, the t-test was corrected for unequal variances (Field, 2009). The result of this t-test demonstrates that the difference is significant, $t = -3.89$, $df = 49.34$ and $p < .001$.

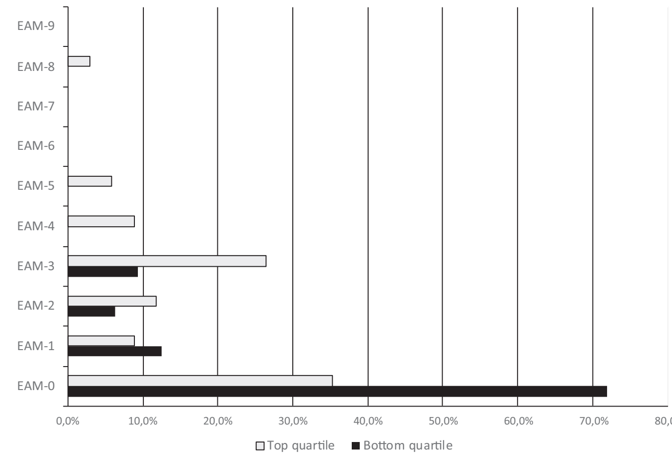

Fig. 6. Percentage of cases per EAM scale per quartile.

Table 11 illustrates the differences between top and bottom quartile cases with regard to the different levels of maturity for all construct dimensions (focus areas) that constitute DyAMM. Top quartile cases score higher on the highest maturity level of all construct dimensions compared to bottom quartile cases. Table 11 demonstrates a big difference on the construct dimension *relationship to the as-is state*. Almost 80% of the top quartile cases are at level B, while more than 80% of the bottom quartile cases are still at level 0 and A. Other construct dimensions with rather big differences are: *management of the architectural products, commitment and motivation, architectural method*, and *interaction and collaboration*.

From this section we can answer research question Q1 and conclude that top quartile organizations are more mature on EA than bottom quartile organizations. This applies both to the overall EA maturity as well as to all the focus areas that underlie it.

5.2. Comparison EA artifacts and insights

We also compared the two quartiles for the types of EA artifacts that are used in the preparation of IT investment decisions and the kind of insights that EA provides in the preparation of IT investment decisions. Fig. 7 demonstrates the differences in use of EA artifacts in the preparation of IT investment decisions. Top quartile cases use more EA artifacts in the preparation of IT investment decisions than bottom quartile cases. With some artifacts the differences are very large. E.g., 82.4% of top quartile cases uses *roadmaps* in the preparation of IT investment decisions compared to 34.4% of bottom quartile cases.

Fig. 8 shows the differences in key insights that EA provides in the preparation of IT investment decisions between top and bottom quartile cases. The overall impression is that EA provides more different insights in the preparation of IT investment decisions in top quartile cases than in bottom quartile cases. For some insights the differences are large, as in *fit with business strategy* with 70.6% of top quartile cases using this insight in the preparation of IT investment decisions compared to only 28.1% of bottom quartile cases.

Figs. 7 and 8 confirm the prominent role of EA in top quartile organizations compared to bottom quartile organizations. Fig. 7 answers research question Q2; organizations with high quality IT investment decision outcomes make more use of, in relative order: *heat maps, policies, roadmaps, business capability models, landscape diagrams*, and *guidelines*. It is also in these organizations where the EA-function provides in general more insights during the preparation of IT investment decisions, especially whether IT

Table 11
Distribution of EAM per maturity level, per construct dimension for top and bottom quartiles.

Construct dimension	Quartile	Level 0	Level A	Level B	Level C	Level D
Development of architecture	Top	32.4	5.9	5.9	55.9	
	Bottom	46.9	3.1	18.8	31.3	
Use of architecture	Top	5.9	26.5	44.1	23.5	
	Bottom	34.4	40.6	18.8	6.3	
Alignment with business strategy	Top	5.9	35.3	35.3	23.5	
	Bottom	43.8	34.4	18.8	3.1	
Alignment with realization	Top	11.8	52.9	2.9	32.4	
	Bottom	31.3	62.5	3.1	3.1	
Relationship to the as-is state	Top	5.9	17.6	79.5		
	Bottom	25.0	59.4	15.6		
Responsibilities and authorities	Top	11.8	11.8	32.4	44.1	
	Bottom	31.3	37.5	21.9	9.4	
Alignment with change portfolio	Top	11.8	29.4	29.4	29.4	
	Bottom	43.8	43.8	9.4	3.1	
Monitoring	Top	20.6	14.7	35.3	29.4	
	Bottom	59.4	21.9	18.8	0.0	
Quality assurance	Top	14.7	44.1	32.4	8.8	
	Bottom	46.9	34.4	18.8	0.0	
Management of the architectural process	Top	2.9	50.0	26.5	20.6	
	Bottom	37.5	40.6	21.9	0.0	
Management of the architectural products	Top	2.9	38.2	50.0	8.8	
	Bottom	18.8	71.9	9.4	0.0	
Commitment and motivation	Top	5.9	29.4	26.5	47.1	
	Bottom	31.3	53.1	9.4	6.3	
Implementation of the architectural role	Top	5.9	29.4	2.9	38.2	23.5
	Bottom	18.8	65.6	6.3	6.3	3.1
Architectural method	Top	17.6	14.7	50.0	17.6	
	Bottom	37.5	53.1	9.4	0.0	
Interaction and collaboration	Top	8.8	32.4	8.8	50.0	
	Bottom	31.3	53.1	9.4	6.3	
Architectural tools	Top	8.8	52.9	14.7	23.5	
	Bottom	37.5	50.0	12.5	0.0	
Budgeting and planning	Top	17.6	47.1	29.4	5.9	
	Bottom	62.5	25.0	9.4	3.1	

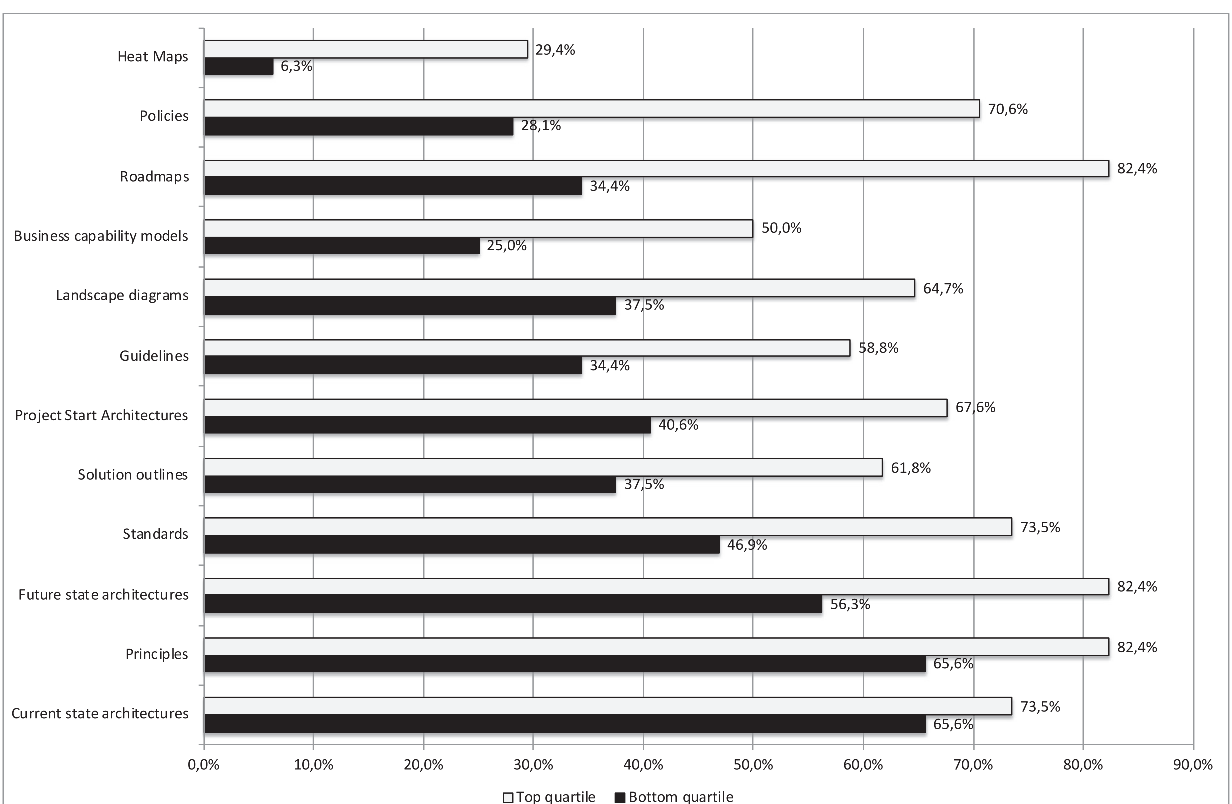

Fig. 7. EA artifacts used in the preparation of IT investment decisions.

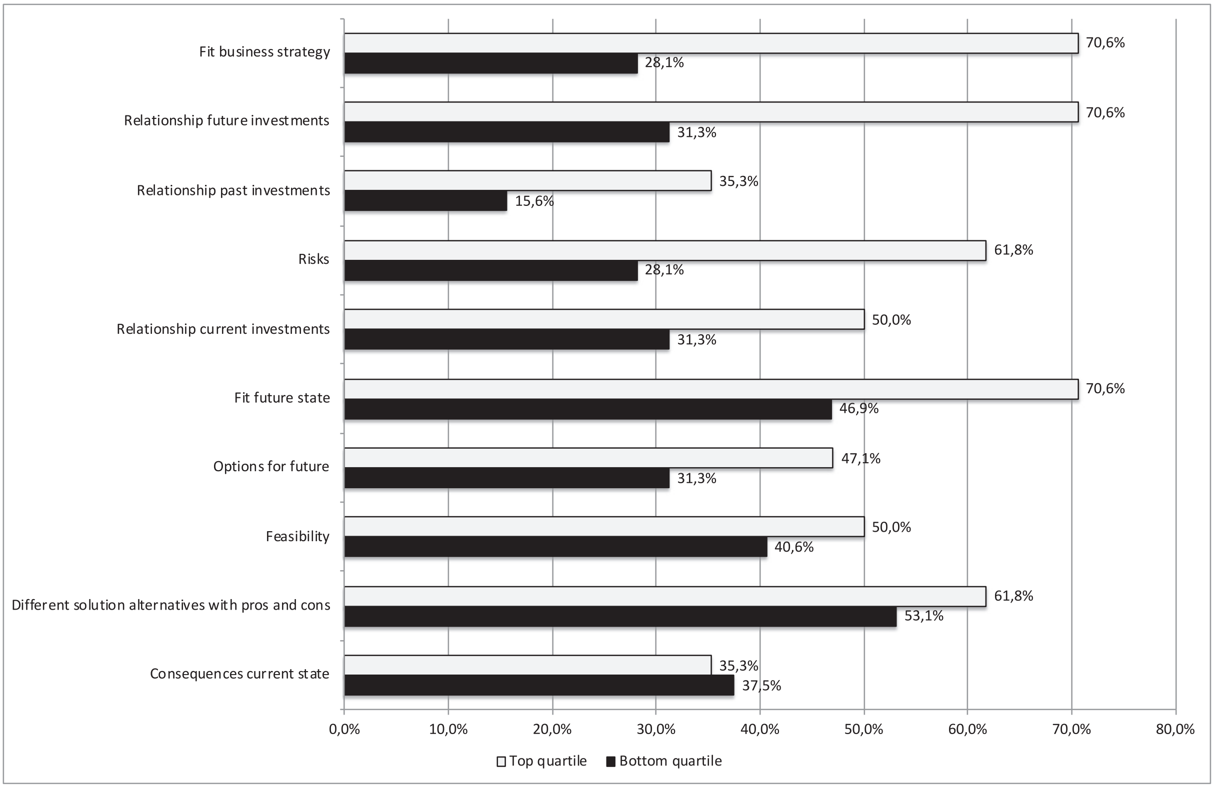

Fig. 8. Key insights that EA provides in the preparation of IT investment decisions.

Table 12
Results of Pearson chi-square tests usage of EA artifacts, significance, value, and degrees of freedom.

Usage of EA artifact	*p*	Value	*df*
Roadmaps	.000	15.70	1
Policies	.001	11.89	1
Heat maps	.015	5.95	1
Future state architectures	.021	5.32	1
Standards	.027	4.91	1
Landscape diagrams	.027	4.89	1
Project start architectures	.028	4.86	1
Business capability models	.036	4.38	1
Guidelines	.047	3.96	1
Solution outlines	.049	3.88	1
Principles	Not significant		
Current state architectures	Not significant		

investments *fit with the business strategy*, the *relationship of IT investments with future and past IT investments*, and the *risks of IT investments*. Fig. 8 therefore answers research question Q3.

We performed Pearson chi-square tests with the usage of EA artifacts and the usage of EA insights as dependent variables and OQ as the independent variable, to determine whether the differences between the top and bottom quartile group are significant. The results in Table 12 demonstrate that top quartile organizations use significant more *roadmaps, policies, heat maps, future state architectures, standards, landscape diagrams, project start architectures, business capability models, guidelines and solution outlines* in the preparation of IT investment decisions compared to bottom quartile organizations. Table 13 illustrates that top quartile organizations use three EA insights significantly more often in the

Table 13
Results of Pearson chi-square tests per EA insight, significance, value, and degrees of freedom.

EA insight	*p*	Value	*df*
Fit with the business strategy	.001	11.89	1
Relationship with future IT investments	.001	10.21	1
Risks of IT investment	.006	7.52	1
Relationship with past IT investments	Not significant		
Relationship with current IT investments	Not significant		
Feasibility of IT investment	Not significant		
Fit with the future state architecture	Not significant		
Consequences for the current state	Not significant		
Options for the future	Not significant		
Different solution alternatives and their pros and cons	Not significant		

Table 14
Definitions of constructs used in the propositions.

Construct	Definition
Maturity EA practice	The overall EA maturity indicated by the scales of maturity (columns) in DyAMM with possible values between 0 and 12.
Quality of IT investment decision outcomes	The overall quality of IT investment decision outcomes indicated by six individual items: • The desired outcomes of IT investments are achieved. • Stakeholders are satisfied with the final outcomes of IT investments. • The final outcomes of IT investments contribute to strategic, long-term objectives. • The due dates of IT investments are achieved. • IT investments are implemented on a timely basis. • IT investments are on budget.
Percentage of actionable and diagnostic EA artifacts used in the preparation of IT investment decisions	Actionable EA artifacts are "signature-ready deliverables that directly drive or guide change by initiating projects or providing direction to change projects" (Burke and Burton, 2017). E.g., a roadmap. Diagnostic EA artifacts are artifacts "that provide the details and results of analysis" (Burke and Burton, 2017). E.g., a heat map. The percentage of actionable and diagnostic EA artifacts used in the preparation of IT investment decisions is compared with the total number of EA artifacts used in the preparation of IT investment decisions.
Percentage of strategic types of insights that EA provides in the preparation of IT investment decisions	Strategic types of insights provided by EA are insights with a rather long term and holistic perspective. E.g., the alignment of an IT investment with the business strategy. The percentage of strategic types of insights used in the preparation of IT investment decisions is compared with the total number of insights that EA provides in the preparation of IT investment decisions.
Maturity on Relationship to the as-is state	The maturity on construct dimension Relationship to the as-is state as part of DyAMM with possible values of 0, A or B and described as: "architecture is frequently associated with a desired state of affairs: the so-called to-be state. Most organizations also have to deal with an existing situation based on historical growth. In assessing the suitability of the architecture, it is important to realize that a set of circumstances already exists, which has its own range of possibilities and impossibilities. If this relationship to the as-is state is ignored, there is a danger that the organization will be able to do little with its elegantly drafted scenarios for future architecture" (Van Steenbergen et al., 2012).
Maturity on Commitment and motivation"	The maturity on construct dimension Commitment and motivation as part of DyAMM with possible values of 0, A or B and described as: "commitment and motivation of the architecture stakeholders is critical in bringing the architecture up to speed and making it successful. These stakeholders include not only the architects but also, and especially, senior business and IT management, plus project management. Business and IT management are primarily responsible for creating a favourable atmosphere. This ensures that the architectural process is given sufficient time, money and resources. Ideally, there is support for the architectural artifacts at all levels of management" (Van Steenbergen et al., 2012).
Maturity on Interaction and collaboration	The maturity on construct dimension Interaction and collaboration as part of DyAMM with possible values of 0, A or B and described as: "a great deal of interaction and collaboration among various stakeholders is required in developing architecture. Stakeholders like business managers, process owners, information managers, project managers, and IT specialists are involved. This interaction and collaboration is very important in making the architectural process function well. They make the architectural requirements clear and they create an opportunity to share the results of the architectural process with the users of the architecture" (Van Steenbergen et al., 2012).

preparation of IT investment decisions compared to bottom quartile
organizations: *fit with the business strategy, relationship with future investments* and *risks of IT investments*.

6. Towards a conceptual model

This study allows us to build new theory with regard to the effectiveness of EA. Based on the findings of this study, we derived propositions that will be presented in this section. At the end of the section we present a conceptual model that integrates these propositions. The propositions are based on seven constructs that are defined in Table 14.

Our results clearly demonstrate that top quartile organizations have an EA practice that is more mature than bottom quartile organizations. Furthermore, the *t*-test demonstrates that the difference between the top and bottom quartile group is significant. Apparently, EA contributes to the quality of IT investment decisions. This is supported by literature that says that EA guides and informs IT investment decisions (Blosch and Burton, 2014; Gøtze, 2013; Buchanan and Soley, 2002; CIO Council, 2012; Janssen, 2012). Therefore, we posit:

P1. *There is a positive relationship between the maturity of an EA practice and the quality of IT investment decision outcomes.*

Top quartile organizations use more and different types of EA artifacts in the preparation of IT investment decisions. Differences in the use of different types of EA artifacts between top and bottom quartile organizations are particularly intriguing. The largest and significant differences can be found in *heat maps, policies*, and *roadmaps*. The smallest, and not significant differences are in *principles* and *current state architectures*. The focus group participants had the following explanations with regard to *principles* versus *policies*: “*Principles give a very global direction and delineation. The question is to what extent principles contain sharp choices. Policies contain much harder choices. So, they have much more impact*”. *Future state* and *current state architectures* can be regarded as the groundwork for EA; documenting the current state and designing the future state are the basis for a gap analysis (Wang et al., 2008; Bittler and Kreizman, 2005). Without that gap analysis there is a risk that EA becomes “shelfware” (Bittler and Kreizman, 2005). *Roadmaps* and *heat maps* can be considered as artifacts that provide insight in the gap. Gartner introduced the term “Business-Outcome-Driven-EA” which in their view is a “strategic discipline focused on developing diagnostic and actionable deliverables that help the business guide investment decisions in support of executing business strategy" (Brand et al., 2017). Diagnostic deliverables are coined as "deliverables that provide the details and results of analysis" (Burke and Burton, 2017). A *heat map* is a typical example of a diagnostic deliverable. Actionable deliverables are "signature-ready deliverables that directly drive or guide change by initiating projects or providing direction to change projects" (Burke and Burton, 2017). A *roadmap* is a typical example of an actionable deliverable. Tamm et al. (2015), in their case study of an Australian retailer, confirm the added value of using an EA roadmap: "it provided visible benefits in improved project sequencing and understanding of critical project interdependencies". Opposed to diagnostic and actionable deliverables are so called enabling deliverables. Enabling deliverables are "deliverables that are composed of information that is collected, providing input to diagnostic deliverables" (Burke and Burton, 2017). A typical example of such an enabling deliverable is a *current state architecture*. Enabling deliverables are necessary to create diagnostic and actionable deliverables but have less value in themselves in guiding investment decisions. Our research reveals that the EA artifacts used in the preparation of IT investment decisions in top quartile organizations are more diagnostic and actionable than those in bottom quartile organizations. We therefore posit:

P2. *There is a positive relationship between the percentage of actionable and diagnostic EA artifacts that are used in the preparation of IT investment decisions and the quality of IT investment decision outcomes.*

Top quartile organizations use more and different types of insights in the preparation of IT investment decisions. Insights into the *fit with business strategy, relationship with future investments*, and *risks of IT investments*, demonstrate big and significant differences between top and bottom quartile organizations. In general, these types of insights are related to the bigger picture of an IT investment and are rather strategic. One of the focus group members commented: "*When it comes to decision-making it is always about strategy and risks; the future so to say*". *Feasibility of IT investments, different solution alternatives*, and *consequences for the current state*, show the smallest and not significant differences. These types of insights are more related to an IT investment sec, and rather tactical. Apparently, EA provides more strategic types of insights in top quartile organizations. We posit:

P3. *There is a positive relationship between the percentage of strategic types of insights that EA provides in the preparation of IT investment decisions and the quality of IT investment decision outcomes.*

Some areas of EA maturity stand out. The most striking is the *relationship to the as-is state*. There is a big difference between top and bottom quartile organizations in the way they connect future and existing situations. In one of the focus groups it was remarked: *"Relationship to the as-is state is a confirmation that you only can create a roadmap when you know the current situation and the gap with the desired situation"*. Top quartile compared to bottom quartile organizations are more focused on the analysis of the current state and connecting future and current state: "*There (in top quartile organizations) a more IT strategy-like architecture vision is created. Because there are the heat maps, roadmaps, landscape diagrams and capability models*" and "*Overview starts with landscape diagrams and heat maps and from that overview we can determine what are we going to do with roadmaps*". Tamm et al. (2015) support the need to connect future and current state. The case study organization they studied created a roadmap for a successful business transformation based on a baseline (current state) and a vision (future state). We posit:

P4. *There is a positive relationship between the maturity on Relationship to the as-is state and the percentage of actionable and diagnostic EA artifacts that are used in the preparation of IT investment decisions.*

A finding from this research is that EA provides more strategic insights in the preparation of IT investment decisions in top quartile organizations compared to bottom quartile organizations. Some EA maturity areas can possibly explain the differences in the percentages of strategic insights that EA provides between

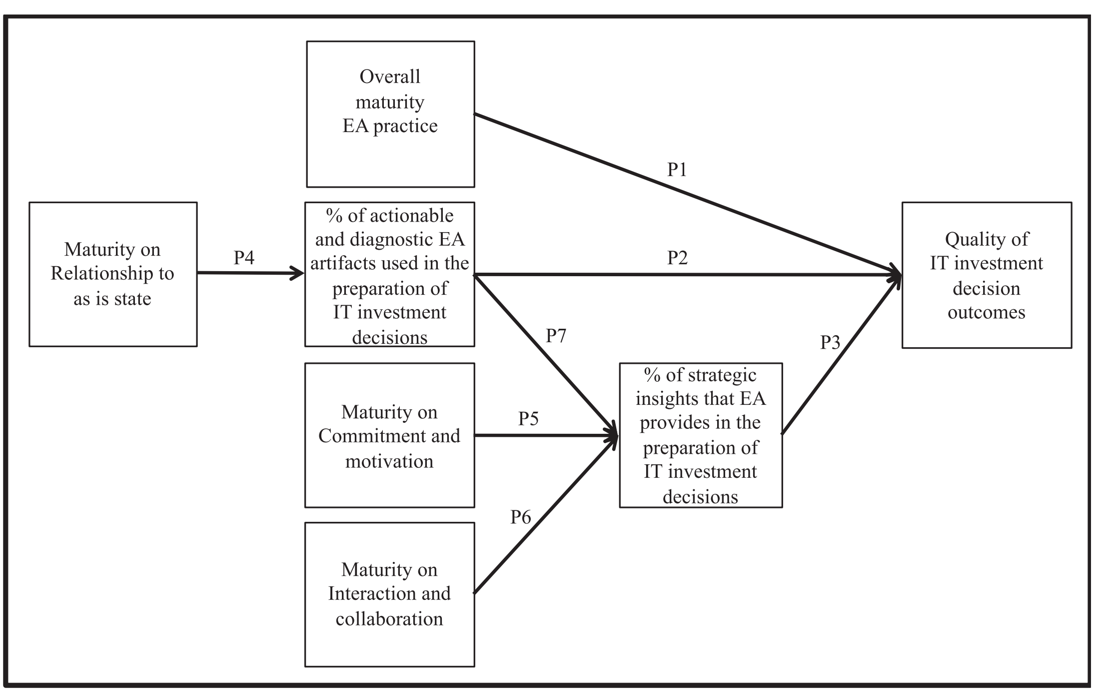

Fig. 9. Resulting conceptual model.

top and bottom quartile organizations. Top quartile organizations demonstrate a higher *commitment and motivation* for EA, and *interaction and collaboration* is also on a higher level. These areas in particular, can be seen as prerequisites for enterprise architects to be part of IT investment decision processes and provide decision-makers with insights (Ylmäki, 2006). Lapalme argues, in case of the enterprise integrating school, that "because the enterprise beast is complex, designs are achieved through team-based processes, so collaboration and enterprise-wide commitment are essential" (Lapalme, 2012). Several authors point out the importance of collaboration (Bente et al., 2012; Gøtze, 2013; Tamm et al., 2015). This is why we posit:

P5. *There is a positive relationship between the maturity on Commitment and motivation and the percentage of strategic insights that EA provides in the preparation of IT investment decisions.*

P6. *There is a positive relationship between the maturity on Interaction and collaboration and the percentage of strategic insights that EA provides in the preparation of IT investment decisions.*

Finally, we argue that the higher the percentage of actionable and diagnostic EA artifacts, the more and better the insights that EA can provide in the preparation of IT investment decisions. This research demonstrates that top quartile organizations use more EA artifacts, especially the actionable and diagnostic ones. It is also in these organizations where EA provides more strategic insights. Therefore, we posit:

P7. *There is a positive relationship between the percentage of actionable and diagnostic EA artifacts and the percentage of strategic insights that EA provides in the preparation of IT investment decisions.*

Fig. 9 shows the resulting conceptual model with the relationships between the different concepts that we discussed. Each concept is represented as a rectangle. An arrow represents the relationship between two concepts. The direction of the arrow indicates the dependency between the two concepts. E.g., the maturity of an EA practice positively impacts the quality of IT investment decision outcomes as explained in proposition one (P1).

7. Implications and limitations

This research is important for decision-makers, practitioners, and researchers. For decision-makers such as COOs and CIOs, this research demonstrates which artifacts and insights they need to ask their enterprise architects when preparing IT investment decisions. This research should also convince decision-makers that maturing their EA practice pays off. Practitioners can use the conceptual model as a guide to become more successful in their support of IT investment decisions. The most important lesson for practitioners is that they should tailor their artifacts and insights to decision-makers. A set of principles or a future state architecture is likely to provide insufficient support for IT investment decisions. Next to these artifacts, heat maps, policies and roadmaps should be considered to aid in IT investment decision-making. Researchers are provided with frameworks to measure the contribution of EA and the outcomes of IT investment decisions as well as insights to further investigate the benefits of EA in relation to IT investment decisions. Scientific knowledge of EA's successful contribution to IT investment decisions has been expanded.

Our study contains limitations. First, this research is based on comparisons of top and bottom quartiles. We derived propositions from quantitative data collected by means of a survey. Although we found some significant differences between top and bottom quartiles, these groups are too small to generalize these propositions. This calls for further research to statistically test these propositions. Second, the typology and classification of EA artifacts and EA key insights require further elaboration. The typology of EA artifacts and EA insights is not limitative and based on different sources which can be subject to different interpretations. We classified artifacts into diagnostic, actionable and enabling, and insights into strategic and not strategic. These classifications call for further tightening and substantiation. Third, the results may have been influenced by the fact that respondents are affiliated to a specific EA school of thought (Lapalme, 2012). As a result, these respondents may follow a different path to EA maturity than DyAMM. We have not included EA schools of thought in this study. Fourth, although this research was not limited to geographical boundaries, more than half of all respondents are from one country, i.e., the Netherlands. The results' validity might be limited to this geographical area. Fifth, we allowed multiple participants from one organization. At least 12% of all cases consist of multiple questionnaires referring to the same organization. This might have an impact on the validity of our results. Sixth, our measurement model measures perceptions. As a consequence, this research may contain biases of respondents. Any form of bias cannot be excluded, although we took measures to guarantee reliability and representativeness of the data. Seventh, Table 10 indicates that respondents who are responsible for IT investment decisions are more represented in the top quartile group than respondents who are consulted and informed about IT investment decisions. We are aware that respondents who are responsible for IT investment decisions could be biased to give more positive answers regarding the quality of IT investment decision outcomes.

8. Conclusion

In this study we applied a quantitative approach i.e., we used survey data to generate theory on the use of EA in the support of IT investment decisions. The study reveals that organizations with the highest quality outcomes of their IT investment decisions (top quartile organizations) apply EA differently compared to organizations with the smallest quality outcomes (bottom quartile organizations). What distinguishes these former organizations from the latter, is a higher EA maturity on all EA maturity areas. Top quartile organizations make more use of EA artifacts in the preparation of IT investment decisions, in particular heat maps, policies, roadmaps, business capability models and landscape diagrams. In these organizations EA artifacts are not limited to artifacts that only provide insight and oversight but have evolved to more diagnostic and actionable EA artifacts. It is also in the top quartile organizations where the EA function provides more strategic insights during the preparation of IT investment decisions, especially whether IT investments fit with the business strategy, the relationship with future and past investments and the risks of IT investments. These findings are important given the large amounts invested in IT and the risks associated with these investments. The right EA approach can help organizations to become more successful in their IT investments. Based on the findings of this research we defined seven propositions. Further research is required to test these propositions. This research provides practitioners and decision-makers with insights on how to improve IT investment decisions. Researchers are provided with insights for further researching the benefits of EA with regard to IT investment decisions. This research ultimately demonstrates that investments in EA have a positive relationship with the quality of the outcomes of IT investments.

Declarations of interest

None.

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