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# Using Enterprise Architecture Standards in Managing Information Technology *

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# Using Enterprise Architecture Standards in Managing Information Technology


## Abstract

Organizations increasingly need to build an enterprise-wide capability to leverage technology that is distributed in different business units. Some organizations establish enterprise architecture (EA) standards to enable greater compatibility of IT components and integration of applications and data across the enterprise. Through a firm-level survey, we sought to answer two key questions about the use of EA standards: (1) How do different governance mechanisms affect the use of EA standards? and (2) To what extent does the use of EA standards help organizations to improve the sharing and integration of IT resources across the enterprise? We identified four key governance mechanisms for EA standards management and examined how each mechanism affected the use of EA standards. We also examined how the use of EA standards affects the management of IT infrastructure, applications, and data resources across business units. Our empirical results showed that the use of EA standards is effective in helping organizations to better manage their IT resources. Our study also provides detailed insights into how organizations can set up governance mechanisms to facilitate the use of EA standards in achieving enterprise-wide goals.



Keywords: Enterprise Architecture, Internal Standards, Horizontal IT Governance, Survey.

# Using Enterprise Architecture Standards in Managing Information Technology

## 1. INTRODUCTION

Organizations face growing challenges in coordinating and managing IT resources distributed across business units [68]. The problems are exacerbated in large and geographically dispersed organizations where subunits have considerable autonomy in handling information processing activities. When business units are allowed to manage their individual IT resources in creative and flexible ways [24, 92], IT management in different business units might adopt incompatible standards, thereby creating local IT objectives and operations not aligned with the organization's goals and objectives. This makes it extremely difficult for IT to respond quickly to new business models that require integration across business units [87, 92]. An organization that cannot integrate the information collected in disparate parts of the organization often lack a holistic view of the customer that spans individual products and business units [87]. Furthermore, such organizations often are unable to leverage economies of scale by sharing knowledge, applying best practices, and reusing technologies across business units [24], resulting in higher IT development and maintenance costs [24]. The increasing proliferation of IT products and the greater complexity of their applications and of the IT infrastructure [6] often make the coordination problem worse by creating more confusion about how IT resources should be managed and what technological choices should be made [72]. Organizations thus face an increasing need to build an enterprise-wide capability to make more effective use of technology distributed in different business units [7].

One way to solve the problems discussed above is to define Enterprise Architecture IT standards (EA standards) to guide IT departments and business units in their technical choices and project-level decisions related to data and application design. EA standards are a set of policies, rules, and guidelines that form unifying principles and practices across projects and business units; they provide the organizing logic for applications, data, and infrastructure technologies [75]. The use of EA standards enables organizations to influence the actions of subunits without dictating exactly how they handle all of their information processing activities. Many practitioners [e.g., 40], researchers [e.g., 72, 74], and standards

organization (e.g., The Open Group[1]) have advocated the use of EA standards to manage IT resources throughout the whole organization.

While the use of EA standards can potentially help organizations to solve coordination problems across business units, a standardization approach involves trade-offs. While standardization has long been associated with an increase in overall efficiency [e.g., 51, 66], it often restricts the options of business units, thus resulting in a less optimal local solution [44, 74]. Hence, not all organizations choose to adopt a standardization approach [5]. Nevertheless, the use of EA standards to plan and coordinate IT resources across an enterprise has been considered a useful approach since the early 1990s [72] and has taken on a more significant role recently with the increasing popularity of technologies such as web services that build upon well-defined architectures. Many research [e.g., 5, 47, 49, 55] and practitioner [e.g., 20, 40, 41, 74] articles highlight the potential benefits of using EA standards. However, little empirical research has been conducted to verify these claims. Hence, in this study, we examine whether the use of EA standards helps organizations achieve the objectives of better sharing and integration of IT resources.

Conformance to EA standards does not occur automatically with the decision to use these standards, especially in multi-unit organizations. Therefore, having appropriate governance mechanisms is important to facilitate the implementation of EA standards [83]. Researchers have come to understand that to address horizontal integration and coordination within an enterprise, organizations must fundamentally address issues related to IT governance [11, 68]. The focus of prior research on IT governance has been on centralization versus decentralization of IT decision making, but IT governance goes beyond this issue [68, 78, 79]. In this paper, we expand the conceptualization of IT governance to examine the types of governance mechanisms that organizations adopt to facilitate the use of EA standards. Our work gives detailed insights into how organizations set up governance mechanisms to support effective use of EA standards in achieving enterprise-wide goals.

In this paper, we examine two key research questions: (1) How do different governance mechanisms affect the use of EA standards? and (2) To what extent does the use of EA standards achieve

[1] http://www.opengroup.org/

the objectives of improving sharing and integration of IT resources across the enterprise? We first provide a detailed description of EA standards and identify the key types of IT resources to be coordinated across business units. Next we present hypotheses about governance mechanisms expected to influence the use of EA standards. We then examine the effects of using EA standards and hypothesize about how using EA standards would help organizations to effectively manage their IT resources. Next we describe the research methodology and design of the firm-level cross-sectional survey conducted to test the research model. We finally present results of the survey study and discuss the main research findings and implications.

## 2. THEORY AND RESEARCH MODEL

EA standards specify the logical organization of corporate IT infrastructure, enterprise data and information, and applications that support core business processes [36, 67]. They provide principles to guide decision making related to the acquisition, deployment, and management of IT resources. Well-stated standards should guide the enterprise to choose technology alternatives consistent with the business direction of the enterprise [92]. EA standards can be documented in many ways, including plain text, pictures, diagrams, and engineering blueprints. They may vary in formality, from high-level guidelines to detailed models, and be represented in specification languages such as the Unified Modeling Language (UML) [63].

***Potential Advantages.*** EA standards provide a roadmap to organizations for introducing technology, data, and process standardization and integration across the enterprise [74]. Several practitioners have claimed that EA standards can provide cost and efficiency advantages if they are used effectively [1]. By standardizing across different technologies, vendors, platforms, and application architecture, some researchers argue that organizations can reduce the complexity of their operations, control the number of skills required to maintain their IT systems, minimize waste and replication within the organization, and enable reuse of IT components and services [1, 47]. Others point out that EA can also help organizations to achieve the goals of integrating their applications and sharing data across various business units [76]. This enables a firm to streamline and integrate business processes, develop key applications more rapidly, and make effective use of organizational data [1, 74].

***Potential Problems.*** To make effective use of EA standards, organizations need to commit substantial amounts of time and resources to create, implement, and maintain the standards [47]. The right stakeholders need to be involved to create a set of standards that meet the business needs of the organization. The scope of the architecture should also be carefully managed, as architecture models too broad in scope can take years to build, only to become obsolete upon completion [31-33]. Moreover, EA standards will have no effect if the IT organization and business units do not conform to it [31]. Thus, organizations implementing EA standards must make sure that there is compliance throughout the organization. After implementation, resources are required to continually update and review the standards to make sure that they remain relevant [92].

Given the potential benefits to and problems with using EA standards, two questions arise: (1) Are the claims about the benefits of using EA standards valid? and (2) What governance model should organizations adopt to facilitate the use of EA standards? The rest of this section will draw on the relevant literature to build a research model to address these two fundamental issues. An overview of our research model is provided in Figure 1.

Figure 1 About Here

### 2.1. Four Dimensions of EA Standards

We first identify the key types of IT resources to be managed across an enterprise and the EA standards that organizations use to manage each resource. IT resources can be divided into two categories: (1) IT infrastructure, which includes the shared technology and technology services across the organization, and (2) specific business applications that utilize the infrastructure, such as the purchasing systems or sales analysis tools [36, 54]. The IT infrastructure can be subdivided further into physical IT infrastructure and human IT infrastructure [10]. Business applications, on the other hand, can refer to either the applications (functions and relationships between applications and installation of applications) or the data (data assets, use, and storage) [92]. Based on the above, there are four key types of IT resources identified in the IS literature and in IS textbooks [30, 73]: technology, people, application systems, and data. We thus differentiate between EA standards used to manage these four types of IT resources:

1. **EA standards for physical IT infrastructure management** are used to standardize underlying technologies required to run business applications, such as computers, networks, routers, servers, peripherals, operating systems, database management systems, system services, and other assorted middleware used as a platform for the construction of application systems in an enterprise [2, 26].
2. **EA standards for human IT infrastructure management** are used to manage the human IT resources, including organizational IT skills, expertise, competencies, and knowledge [48].
3. **EA standards for business application integration** define strategic directions for managing the application portfolio and technologies for integrating applications [49].
4. **EA standards for enterprise data integration** highlight critical data elements and databases to be integrated across the organization and provide a definition of the data elements on which to focus [31].

### 2.2. Governance Mechanisms for EA Standards Management

IT governance has been defined as "the distribution of IT decision-making rights and responsibilities among enterprise stakeholders, and the procedures and mechanisms for making and monitoring strategic decisions regarding IT" [68, p. 8]. We focus on horizontal IT governance mechanisms [11], which are mechanisms designed to facilitate cross-unit collaboration with regard to setting and using EA standards. The setting and use of EA standards is a task that requires coordination across business units, so as to increase the likelihood that the standards will be used and followed in the organization. While this coordination may be done informally or through the determined efforts of one or more well-connected and enthusiastic personnel, such informal and ad-hoc efforts are highly dependent on individuals and the process is generally not repeatable. Hence, we focus on examining the formal governance mechanisms that organizations institutionalize to coordinate the task of setting and using EA standards across business units.

The focus of past research on IT governance had been on whether the locus of IT control should be centralized or decentralized [68, 78, 79], but this narrow perspective no longer corresponds with what is happening in the real world, where companies use a portfolio of different governance mechanisms [79]. Sambamurthy and Zmud noted that the issue of centralizing or decentralizing IT decision making "was not

the only, or even a major, theme" [79, p. 106] in their case studies. In this study, we expand the current conceptualization of horizontal IT governance mechanisms and explore the types of mechanisms that organizations use to govern the use of EA standards.

### 2.2.1 Prior literature on horizontal IT governance mechanisms

There are many structural and non-structural governance mechanisms for achieving coordination across business units [11]. Organizational theorists [22, 27, 28, 56, 60] view horizontal mechanisms as a continuum, based on their increasing ability to handle more complex forms of coordination across units [11]. Mechanisms that provide greater lateral coordination are often more costly to implement. Figure 2 provides an illustration of this continuum adapted from Brown [11] and Daft [22].

Figure 2 About Here

Mechanisms at one end of the spectrum, such as having direct contact among managers of business units, offer modest forms of information processing and coordination. The next step along this continuum is the creation of special liaison roles. A liaison is located in one department but has the responsibility of communicating and achieving coordination with another department; such a role is usually performed in conjunction with other activities [56, 60]. A more costly but effective way to coordinate across units is to use formal groups and integrating roles to facilitate collaboration across different departments. Integrating roles are filled by individuals outside any specific department who have the explicit responsibility of coordinating several departments [56].

In addition to these mechanisms, Peterson [68] highlights the importance of developing monitoring processes. Peterson [68] classifies governance practices into three categories: relational, structural, and process. He defines relational IT governance as more informal collaborative relationships among stakeholders and executives. [2] Structural IT governance mechanisms refer to formal ways to connect and enable horizontal contacts between business and IT management functions. The liaison and integrating roles and teams discussed by Brown [11] and the organizational theorists fit into this category. The key mechanisms include the use of formal positions and integrating roles and/or formal groups and

[2] We did not use this category of governance capability as we are only examining formal IT governance mechanisms.

management teams. Finally, process IT governance is defined as the formalization and institutionalization of IT monitoring processes. Process capabilities describe the degree to which rules and standard procedures are specified for IT monitoring. These procedures are often embedded in formalized decision-making methodologies. To facilitate the use of EA standards, processes are needed to ensure that the standards are defined and implemented well at the working level. Hence, we explore the types of processes that would facilitate the work of the architects in setting and implementing EA standards.

Applying the theory from the literature to the case of setting and using EA standards, we mapped the EA governance mechanisms discussed in the practitioner literature [40, 88] to the following categories of horizontal IT governance mechanisms based on Brown [11] and Peterson [68]:

1. **Define key architecture roles:** The most costly and effective set of mechanisms for complex coordination [11, 56, 60] include defining integrating managerial, team, and architecture roles to govern the setting and use of EA standards.
2. **Institutionalize mechanisms to involve key stakeholders:** Less costly mechanisms with less information processing capability [11, 56, 60] include using liaison roles to act as boundary spanners and defining mechanisms to facilitate direct communication between business users and the architecture team.
3. **Institutionalize monitoring processes for EA standards:** This category of IT governance mechanisms describes processes organizations use to monitor the setting of and conformance to EA standards.
4. **Centralize IT decision making:** In line with prior literature, we examine how the centralization of IT decision making would affect the use of EA standards in organizations.

In the following sections, we describe each governance mechanism in detail and hypothesize about how each type of mechanism affects the use of EA standards. We do not hypothesize that there will be any differences in how these four constructs would affect the use of different types of EA standards (i.e. EA standards for physical IT infrastructure, human IT infrastructure, business applications, and enterprise data). In our empirical analysis, however, we do examine whether the results of the hypotheses is similar for all four types of EA standards. The insights based on this exploratory analysis will provide significant guidance for future research in understanding the differential impact of each type of EA governance mechanism.

### 2.2.2 Define key architecture roles

To facilitate EA standards use, organizations frequently create roles that provide specific individuals with authority and responsibility to spearhead and accomplish various EA tasks and projects [40, 65, 82]. This provides greater accountability for the task of coordination across units [60]. The practitioner literature highlights four key architecture roles: (1) EA management team; (2) chief architect; (3) architecture teams; and (4) key EA stakeholders. We provide more explanations of the roles below.

***EA Management Team.*** The use of IS steering committees is associated with effective coordination of IS planning activities [43] and increased managerial support and funding [90]. IS steering committees bring different interest groups together and are effective in getting top management and users involved in the management of IT [71]. Several practitioner EA frameworks [40, 88] have highlighted the need for an architecture management team, or architecture board, which is a governance body responsible for guiding and making high-level decisions about EA standards.

***Chief Architect.*** To manage EA standards, some organizations appoint a chief architect, or architecture leader, who is the primary individual responsible and accountable for leading the efforts for defining EA standards [40, 88]. Having such a managerial integrating role is important for defining an effective set of EA standards and for bringing about conformance to the standards, as s/he has sufficient authority at the managerial level to champion the setting and use of EA standards.

***Architecture Team.*** The setting of EA standards is a complex undertaking that requires the efforts of many dedicated personnel because of the skills and the intense efforts required to actively coordinate multiple stakeholders and monitor the use of the EA standards [67]. Architecture teams – individuals whose primary job responsibilities are to define and manage the IT architecture – are needed to handle the operational aspects of managing EA standards, and to implement the strategic directions set by the EA management team and chief architect. In many organizations, the architecture team is further divided into sub-teams to handle EA standards for technical infrastructure, business applications, and enterprise data.

***Key EA Stakeholders.*** Stakeholders for EA standards are the representatives from business groups or IT groups affected by EA standards who are invited to provide inputs in the EA setting and management

process. Typically there are three sets of stakeholders or potential users of the EA standards [67]: corporate IS, divisional IS, and the managers and users in business units [78]. These stakeholders are either IT personnel implementing systems that conform to the EA or the end-users making use of the systems built based on the EA standards.

The EA management team and chief architect facilitates the governance of EA standards at a strategic level. At the operational level, the appointment of architecture teams provides accountability for standards setting, and the identification of stakeholders enables inputs to be sought from the right people. Figure 3 provides an overview of the relationships between the key roles identified above.

Figure 3 About Here

We thus hypothesize:

**H1a:** Organizations that appoint key architecture roles are more likely to see greater use of and conformance to EA standards.

#### 2.2.3 Institutionalize mechanisms to involve key stakeholders

It is important to involve key stakeholders in the standards setting process for EA standards for two reasons: (1) key stakeholders are the "owners" and "stewards" of operational data and processes, and have the most influence on whether the EA standards are accepted; (2) key stakeholders are the best source of subject matter expertise. Stakeholder involvement can be solicited by: (1) having formal mechanisms in place to facilitate direct communication between stakeholders and the architecture team; or (2) appointing business analysts to act as liaison between business users and the architecture team.

***Stakeholder Involvement through Direct Communication.*** Mechanisms can be established to facilitate direct communication [56] and interaction between the architecture team and stakeholders during the process of defining, setting, and communicating the architecture standards. Communication between the architecture team and stakeholders not only enables business interests to be represented, but it also allows architects to communicate the value of the standards to users and IT personnel and to educate them about the importance of adhering to the architecture. Moreover, frequent communication among stakeholder

groups enables them to share a common frame of reference [17] with regard to various organizational EA issues and provides feedback loops for improving the EA standards.

***Stakeholder Involvement through Liaison Roles*.** Stakeholder involvement can also come about through a liaison, such as a business analyst, who is designated to serve as a boundary spanner between the architects, IT personnel, and business units [91]. Business analysts determine the needs, requirements, and constraints of business units that should be considered in the setting of architecture standards. Business analysts add value by clarifying the key requirements of the business and achieving consensus among their own business units [69]. Analysts also educate users about the architecture standards, and they act as a channel through which new or changing requirements are communicated to the architecture team.

Governance mechanisms to facilitate interaction between stakeholders and architects enable EA standards to be set with adequate consideration of key stakeholders' needs. This results in greater buy-in, thus increasing conformance to EA standards. We hypothesize:

**H1b:** Organizations that have mechanisms to facilitate stakeholder involvement are more likely to see greater use of and conformance to EA standards.

### 2.2.4 Institutionalize monitoring processes for EA standards

In the past, research on horizontal IT governance mechanisms has focused more on putting in place relevant structures and roles to govern coordination across units [11]. IT governance should, however, specify "both the structures and processes through which the organization's IT objectives are set, and the means of attaining those objectives and monitoring performance" [68, p. 9]. Peterson discussed the institutionalization of monitoring processes as a type of IT governance mechanism. In this study, we explore the types of processes that would facilitate the work of the architects in setting and implementing EA standards in an organization. Based on the practitioner literature and interviews with enterprise architects and consultants, we identified two key aspects that need to be addressed by monitoring processes: (1) setting of standards based on external standards; and (2) standards conformance.

***Standards Setting Based on External Standards.*** A key objective of using EA standards is to control the growth of technical diversity in an enterprise [40], as the rapid adoption of the most state-of-the-

art IT products can easily lead to having a diverse set of incompatible IT products. Enterprise architects must therefore keep themselves up-to-date about latest industry IT standards, assess their potential impact on IT operations, and determine if there is a need to change internal standards to maintain compatibility with current industry standards [8]. Using external standards also provides assurance that many choices will be available for systems implementation and that there will be people with the IT skills required to implement and maintain the systems chosen [18, 19]. In addition, awareness of industry standards enables organizations to build on the industry knowledge embedded in external standards that have been deliberated upon and scrutinized by companies in the industry [53].

***Standards Conformance.*** Standards are useless without compliance [31]. Conformance to standards, however, does not happen automatically, as standards usually restrict the choices of users and require changes to existing practices. Furthermore, conformance often involves some sacrifices in the optimal design of local systems or may cause project teams to incur higher costs in the short run [33, 84]. Thus, it is essential to have governance mechanisms to ensure conformance to architecture standards, such as procedures that provide sanctions for non-compliance (e.g., denial to approve purchase requests and refusal to maintain non-standard technology) [44]. Conformance mechanisms should also grant exceptions to standards where necessary [40]. This builds flexibility into the process and allows non-conformance to architecture standards when there is sufficient reason, while providing for careful deliberation before abandoning conformance to standards for key projects.

In conclusion, it is important for organizations to institutionalize processes that facilitate enterprise architects' work of setting and implementing EA standards. We thus hypothesize:

**H1c:** Organizations that have institutionalized monitoring processes for setting and using EA standards are more likely to see greater use of and conformance to EA standards.

### 2.2.5 Centralize IT decision making

Researchers have extensively examined the impact of centralizing IT decision making on effective management of IT resources [68, 78, 79]. A centralized decision-making structure is present when design authority resides primarily with a central corporate IT unit, whereas a decentralized decision-making

structure is present when decision authority resides primarily with business units [12]. Centralization affords greater efficiencies or economies of scale and greater centralized controls, while decentralization provides local control and ownership of resources and better responsiveness to business units needs [13]. Centralization of IT decision making affects the use of EA standards in several ways. First, centralization increases ease of communication between the architecture team and IT personnel, and provides IT personnel with more opportunities to voice their concerns in the standards setting process. Centralization also makes it less difficult to ensure conformance and to make sure that all exceptions are given due process. As a result, we are more likely to see greater use of and conformance to EA standards in a centralized IT environment. We hypothesize:

**H1d**: Organizations that have greater centralization of IT decision making are more likely to see greater use of and conformance to EA standards.

### 2.3. Outcomes of Using EA Standards

While both the practitioner and research literature have highlighted the potential advantages of using EA standards, only anecdotal evidence of their usefulness exists [e.g., 1, 20, 40, 67] and only case studies discussing the benefits of using EA standards have been reported [5, 72]. Hence, we examine the extent to which the use of EA standards enables an organization to effectively manage the IT infrastructure and integrate business applications and data across the enterprise.

Different types of EA standards are used to manage different IT resources [2, 26] and to achieve a different architectural objective [57, p. 6-7]. In the following sections, we describe each type of IT resource and explain how EA standards are expected to help organizations to effectively manage each IT resource.

#### 2.2.1 Physical IT infrastructure

IT infrastructures play an important role in enabling the sharing of information and expensive resources and connecting to business partners as part of the extended enterprise [14, 15, 25, 50, 58]. Organizations that have heterogeneous IT infrastructure components have diverse technologies from different vendors that are incompatible with one another. Reducing the heterogeneity of infrastructure components would enable organizations to better leverage the investment in physical IT infrastructure across units.

Economies of scale arise from sharing common IT infrastructure components and from better price negotiations with vendors [86]. Moreover, having a large number of different IT platforms to support complicates systems development and increases maintenance costs. Standardizing the IT infrastructure components would allow the utilization of similar skill sets across a wide spectrum of IT activities [1].

In summary, EA standards that reduce the heterogeneity of IT infrastructure components across business units help organizations achieve greater compatibility between infrastructure components, by defining technology standards to limit technology choice, to reduce the number of platforms supported, and to define standard protocols enabling communication between systems. Thus, we hypothesize:

**H2a**: The use of and conformance to EA standards for physical IT infrastructure reduces the heterogeneity of IT infrastructure components across business units.

### 2.2.2 Human IT infrastructure

Physical IT infrastructure is converted into useful shared services by human IT infrastructure that provides reliable IT services such as disaster recovery, telecommunications network services, and security services [48, 92]. When IT management is decentralized in different business units, there is a tendency for units to duplicate efforts in providing similar IT services [10]. The sharing of IT services helps organizations to innovate business processes, share best practices, gain economies of scale [10], and reduce redundancy, wastage, and suboptimal allocation of IT human resources. EA standards helps to reduce the replication of IT infrastructure services provided across business units by establishing common requirements and defining the set of infrastructure services provided by IT personnel that will be shared by several business units [1]. Hence, we hypothesize:

**H2b:** The use of and conformance to EA standards for human IT infrastructure reduces the replication of IT infrastructure services across business units.

### 2.2.3 Business applications

Without effective coordination across business units, individual applications tend to be developed to optimize the local unit's business needs without consideration for overall enterprise goals [45]. Over time, applications become independent silos on multiple technology platforms with their own defined sets of data

[74]. The lack of IT systems integration can create significant problems for organizations [70, 89]. For example, financial institutions that want to consolidate information about individual consumers would require integration across multiple product-specific systems. Application silos are also a hindrance to new application development projects, as it is difficult to link new applications to them [74]. It is thus important for an organization to identify and integrate its key applications [36, 57].

EA standards for business applications describe the core applications required to successfully run the business, along with an appraisal of their strategic value and impact on the business [2, 26, 49]. The standards also define interdependencies and interoperability needs that are required between business applications and identify new applications that will be required to satisfy up-and-coming business needs [2, 26]. Therefore, EA standards not only guide new application projects by defining how the new systems need to inter-operate with existing core systems, but they also guide projects that are targeted at writing programs and interfaces to integrate existing core systems [49]. Furthermore, in cases in which multiple departments, for historical reasons, use different systems for common functions, EA can help identify those systems that should be consolidated. We thus hypothesize:

**H2c:** The use of and conformance to EA standards for business applications improves the integration of business applications across business units.

#### 2.2.4 Data and information resources

Interest in managing electronically stored information has swelled over the past decade [31-33]. Inconsistent data formats and semantics create problems such as incomparable data and information (e.g., performance of business units) and difficulties in coordination (e.g., inventory coordination problems because of inconsistent product coding schemes) [84, 94]. Data integration means the standardization of data definitions and structures through the use of a common conceptual scheme across a collection of data sources. Integration ensures that data have the same meaning and use across time and users and that data in different systems or databases are consistent and compatible [31]. However, prior literature highlights that it is not cost-effective to integrate all of an organization's data [31, 32, 34]. An organization should aim for "partial integration" of data, such as limiting the scope of data integration to only a subset of important

databases or the critical data elements in the organization [31]. EA standards facilitates "partial integration" of data by selecting critical data elements and databases to be integrated across the organization and requiring business units to agree on a definition of the data elements on which to focus. We hypothesize:

**H2d:** The use of and conformance to EA standards for enterprise data improves enterprise data integration across business units.

To summarize, we hypothesize that the key governance mechanisms affecting the use of and conformance to EA standards are: (1) defining key architecture roles; (2) involving key stakeholders through liaison roles and direct communication; (3) institutionalizing monitoring processes for setting and using EA standards; and (4) centralizing IT decision making. The use of EA standards, in turn, affect the management of IT resources by: (1) reducing the heterogeneity of IT infrastructure components across business units; (2) reducing the replication of IT services provided by different business units; (3) enabling better integration across applications in the enterprise; and (4) enabling better integration of enterprise data.

### 2.4. Organizational Control Variables

To test our research model, we included several organizational control variables that are expected to affect both the use of EA standards and the outcome variables. The control variables include organization size, experience, and top management support, which are control factors often included in studies examining the success of IS management [e.g., 4, 14, 49]. We also included a control for the extent to which organizations had problems with legacy systems, because legacy systems can be a significant impediment to systems integration [49, 81, 85]. We also controlled for the importance of each architecture objective, as not all organizations place equal emphasis on standardizing the management of IT resources across their business units. We briefly describe these key organizational control variables below:

1. **Years of architecture experience:** There is a steep learning curve involved in developing proficiency to manage EA standards because of the complexities and sophistication in managing IT resources across the enterprise [36]. Hence, an organization's years of architecture experience is expected to affect their extent of standards use and their effectiveness in managing IT resources.

2. **Importance of architecture objective:** Different organizations place varying amounts of emphasis on different objectives and areas of strategic focus [92]. Not all organizations may wish to adopt a standardization strategy for all IT resources across their business units, as some organizations may feel that standardization would have a negative impact on the flexibility of individual subunits [94]. We asked respondents to rate the importance of each architecture objective and included this variable as a control.

3. **Top management support**: Top management support is an important factor affecting IS projects and IS management [4, 49]. It is important for the use of EA standards due to its role in facilitating the mobilization of resources and its positive influence on users' attitudes toward using and conforming to EA standards. This is especially because the use of EA standards often require changes in IT practices of local business units and a change in culture within the organization's IT community [88].

4. **Problems with legacy systems**: Legacy systems often pose significant problems to organizations in their technology planning and systems integration process [49]. A recent survey found that a large majority of business-technology professionals viewed legacy systems as impediments to their companies' nimbleness [93]. Given that organizations usually cannot afford to throw out their legacy systems and that legacy systems significantly restrict the standards that can be introduced and adopted, legacy systems pose a significant challenge to the ability of organizations to use EA standards effectively.

5. **Organizational size and industry:** Organizational size and industry typically affect an organization's ability to manage their IT resources; hence, we include these variables as controls.

## 3. RESEARCH DESIGN AND METHOD

### 3.1 Methodology

To begin, we conducted exploratory interviews with five organizations and eight architect consultants who have extensive experience working with clients who use EA standards. These initial interviews helped us to understand how EA standards are used in organizations and provided significant insights into key processes and practices that organizations adopt to govern the use of EA standards. We then developed a survey based on our research model and the insights gained from these preliminary interviews. The survey questions were

reviewed with four other architect consultants; each spent two hours reviewing the questionnaire, explaining how they interpreted each question and answer option, and providing estimates of whether organizations would be able to answer each question. We also reviewed the survey with a usability expert and a statistical expert. We then conducted a pilot study in which we surveyed 30 organizations, after which we checked the reliabilities of the scales and examined which questions respondents had the most difficulties answering. We shortened the survey based on this analysis. The responses of the 30 respondents were included in the analysis.

We then conducted a cross-sectional firm-level survey to empirically test our research model and hypotheses. We sampled firms that use EA standards as well as firms that are considering the use of EA. [3] In the survey invitation letter, we stated that the survey was targeted at the chief architect or a person in the organization who had broad architecture responsibilities. Data collection took place between November 2003 and July 2004. The survey was implemented on the web. Survey respondents came from three sources.

1. First, we sent invitations to IBM clients through architect consultants, who were members of an EA virtual community at IBM. The community used a mailing list to keep architects informed about latest updates in the topic area. Through this mailing list, we requested consultants to forward the survey invitation to their client organization and encourage their participation. We also asked consultants to inform us about the invitations they forwarded to their clients. Based on the responses we received from the consultants, we estimate that invitations were sent to 166 client organizations.
2. In addition, we sent a total of 135 survey invitations to participants of an IBM insurance application architecture conference. Participants of this conference were generally very interested in EA.
3. The Open Group, an international consortium that focuses on helping organizations to integrate new technology across the enterprise, helped us disseminate information about the survey to their members and posted the link to our survey on their web site. The Open Group includes a wide range of organizations committed to encouraging greater integration and sharing of IT resources and one

[3] Only four of our respondents were firms that have not used EA standards. Their responses for the questions related to EA governance mechanisms were thus coded as missing, as they have not instituted any governance mechanisms for EA governance. Sensitivity analysis dropping these four responses provided similar results.

subgroup specializes in EA. Through this association, we estimate that invitations were made accessible to 170 organizations.

In total, invitations were sent to 471 organizations. We believe that these three samples are representative of the target population of companies, as they include companies that are particularly concerned with improving coordination across business units in the management of IT resources.

The response rate was most favorable for the IBM client group (51.8%). This is likely because the consultants had direct access to the person in client organizations who would be interested in taking such a survey, and consultants were able to follow up with their clients on multiple occasions to encourage their participation. Table 1 provides a breakdown of the response rate by the three respondent groups. We examined whether there were significant differences in the responses among the three sample groups. Our results showed that the IBM client group had significantly more experience in using EA standards. Hence, we included a control variable in our analysis to indicate whether the respondent was from this group.[4]

Table 1 About Here

We obtained a total of 112 responses. There were four organizations with two respondents each. We averaged the responses for these four organizations, thus obtaining a total of 108 respondents, providing a 22.9% response rate. There were 18 incomplete responses, resulting in 90 complete and usable responses. In return for their participation, respondents received a benchmarking report that compared their performance in enterprise architecture management against other respondents in their industry and overall. (See Appendix A for more information about respondent demographics.)

### 3.2 Operationalization of Variables

The survey instrument items are shown in Appendix B. The items used for this study constitute only part of the survey, which included a total of 129 questions. We adapted survey instruments from prior literature where relevant (e.g., for most of the control variables and for measuring the effectiveness with which each type of IT resource is coordinated across the enterprise). New survey items were created to

[4] We conducted a sensitivity test to examine how our results would differ if we used only the responses that were provided by IBM clients. The results remained unchanged.

assess the extent to which governance mechanisms are used in organizations and the extent of EA standards use, as prior measurements of these constructs were unavailable. These new items were created based on guidance from the literature and based on insights gained from the preliminary interviews.

### 3.2.1 Governance mechanisms for using EA standards

***Defining Key Architecture Roles.*** We asked respondents to identify which of the four key architecture roles their organization had adopted: (1) chief architect; (2) EA management team; (3) architecture team; and (4) key stakeholders. Based on these responses, we calculated the number of architecture roles that each organization has defined. We also asked respondents which of the following architecture teams they had defined in their organization: (a) infrastructure architects, to analyze and set standards for the IT infrastructure components; (b) application architects, to analyze and set standards for applications, internal and external interfaces, and the control and flow of information between applications; (c) information architects, to analyze and set standards about business information (logical and physical) and associated relationships; and (d) business architects, to analyze and document business processes, scenarios, and information flow. [5] We used the number of architecture teams as another indication of the extensiveness of architecture role definition in the firm, as organizations with more architecture teams have greater specialization of skills for handling different types of EA standards.

***Involving Key Stakeholders Through Liaison Roles and Direct Communication.*** We asked respondents to rate the extent to which each architecture team has defined processes to ensure adequate stakeholder representation in the standards setting, changing, and communication process. We also asked them to rate the extent to which business analysts work closely with the architects in each architecture team.

***Institutionalizing Monitoring Processes for Setting and Using EA Standards.*** We asked respondents to indicate the extent to which the work by each architecture team is influenced by and kept up-to-date with external industry standards. For conformance to standards, we asked them to rate the extent

[5] The web survey was dynamically generated based on respondents' selection of architecture teams defined in their organization. Subsequent questions specific to each architecture team were only displayed for the architecture teams that respondents chose. The ratings were then averaged across all architecture teams. We included an option for "other types of architecture team" in our survey, but only two respondents selected this option. Excluding these two respondents from our analysis provides similar results

to which each architecture team has defined processes to ensure adequate conformance and designated means to consider exceptions to conformance.

***Centralizing IT Decision Making.*** In line with prior research [e.g., 12], we differentiate between centralization of IT infrastructure and of IT systems planning and development. For IT infrastructure centralization, we asked respondents to rate the extent to which infrastructure planning and management is centralized in the corporate IT group or decentralized in lines of business. For IT systems development centralization, we asked respondents to rate the extent to which (1) approval and prioritization of application development projects, and (2) IT development and implementation is centralized in the corporate IT group or decentralized in lines of business.

#### 3.2.2 EA standards use

For each architecture objective, we asked respondents to indicate the extent to which (1) the organization had defined formal architecture guidelines and internal standards and (2) members of the organization used and conformed to the formal company-defined architecture guidelines and internal standards.

#### 3.2.3 Outcomes of EA standards use

To assess the outcome of using EA, we examined the extent of (1) heterogeneity of IT infrastructure components; (2) replication of IT services; (3) business application integration; and (4) enterprise data integration in the respondents' organization.

***Heterogeneity of IT Infrastructure Components.*** We adapted the list of IT infrastructure components used by Hamilton [36] to identify three key components. Respondents were asked to rate the extent to which there was heterogeneity in the following components used across projects or lines of business: (1) hardware and network components; (2) middleware; and (3) tools.

***Replication of IT Services.*** We used the list of infrastructure services provided by IT personnel in Broadbent et al. [10] to identify three key types of services that should be shared among business units. Respondents were asked to rate the extent to which multiple groups in different business units provided similar services in: (1) security, disaster planning, and business recovery services; (2) managing electronic linkages to suppliers or customers; and (3) infrastructure services (supporting hardware and middleware).

***Application Integration.*** Respondents were asked what percentage of the key application systems supporting the core business processes were integrated by a common middleware approach (e.g., using "integration bus/hub" or synchronous/ asynchronous messaging). This implies that we are only examining application integration among the core applications of the enterprise. We also asked respondents the extent to which functional boundaries of individual applications and components have been clearly defined.

***Enterprise Data Integration.*** We used four items based on the measures of data management in Duncan [25] and Byrd and Turner [16] to identify the key measures with an enterprise focus that were most relevant to our study: (1) whether the respondent organization had formally and sufficiently identified data to be shared across lines of business; (2) whether the customer entity was perceived and interpreted in a common fashion by all systems and lines of business; (3) whether key business performance indicators extracted from IT systems were readily available to decision makers who required the information; and (4) the percentage of data that the organization would like to share across lines of business that was currently sharable. This set of questions incorporate the idea that the key to enterprise data integration is not to share all data but to identify the right set of data and enable it to be effectively shared across the enterprise.

#### 3.2.4 Organizational factors

Measures for the control variables (provided in Appendix B) were derived from prior literature [e.g., 4, 39, 61] and adapted to the context of EA use.

### 3.3 Test of Factors

Content validity was qualitatively assessed through reviews by experts and through the pre-test. We assessed convergent validity and discriminant validity using principle components analysis (See Appendix C). Out of the 37 item loadings, four did not load high in their factors (loading < 0.5). We dropped three of these items but retained the item measuring centralization of infrastructure management as a separate construct, as it is important to differentiate between centralization of systems planning and development and infrastructure management [12]. The six items measuring three governance mechanisms – defining key architecture roles, involving key stakeholders through liaison roles and direct communication, and institutionalizing monitoring processes for setting and using EA standards – loaded highly on the same

construct. All six items are also highly correlated to one another. However, we decided to retain the governance mechanisms as three separate constructs due to the theoretical distinction between the mechanisms. Reliability of the survey instrument's items was also quantitatively validated by calculating Cronbach alphas for each measurement variable. The standardized alphas range from 0.706 to 0.893 and are itemized in Table 2. The alphas for all constructs are greater than the commonly accepted 0.7 threshold [62].

Table 2 About Here

Convergent validity is demonstrated if items measuring the same factor correlate highly with one another. Appendix D shows the correlation matrix of the survey items retained. Convergent validity is demonstrated as the correlations of all items measuring the same construct were significantly different from zero at the 0.001 level of significance. Discriminant validity is achieved if an item correlates more highly with items measuring the same factor than with items measuring a different factor. The correlation matrix shows that the items retained displayed good discriminant validity, except for the items measuring governance mechanisms. All six items were highly correlated with one another. We retained these items as measures of three separate constructs instead of one construct due to the theoretical distinction between the mechanisms.

To address possible common method bias effects, we performed Harman's single-factor test [37]. If a significant amount of common method bias exists in the data, then a factor analysis of all variables will generate a single factor that accounts for most of the variance. Unrotated factor analysis revealed ten factors, and the first factor explained only 22.2 percent of the variance in the data. We also believe that common method bias is not a major problem in our data for two other reasons. First, a key source of common method bias results from items measuring different constructs with similar content. There is very little overlap in the content of our measures of outcomes, EA standards use, and governance mechanisms for using EA standards. Second, we made use of well-defined scales to assess more objective situations in the organization, such as the measures for the governance mechanisms for managing EA standards. These scales provided a consistent standard for respondents and helped reduce the extent of common method bias.

## 4. DATA ANALYSIS AND RESULTS

We tested the research model and hypotheses using partial-least-squares (PLS)-based structural equation modeling (SEM) [21]. SEM techniques are suitable for estimating multiple and interrelated dependence relationships such as those in our research model. The PLS measurement model provides the loadings of individual items on their variables. Table 3 displays the results of variable loadings analysis in the measurement model in PLS for the final set of retained items. The items loaded highly (>0.75) in their respective constructs. Table 4 displays the descriptive statistics and correlation analysis of the constructs used to test the hypotheses. The highlighted diagonal cells are the square root of average variance extracted and the off-diagonal cells are the correlations between constructs. The values in the diagonal cells are considerably higher than all other cells in the same row, highlighting the high discriminant validity.

Tables 3 and 4 About Here

The structural model of the PLS analysis shows the variance explained ($R^2$), path coefficients, and significance levels of the path coefficients between latent constructs of the research model [29]. Similar to linear regression, an $R^2$ in the PLS analysis provides the strength of the model in predicting each dependent variable. Path coefficients in the structural model specify the strength of each individual relationship. The size, direction and significance of path coefficients provide support, or lack thereof, for hypotheses [9].

We first conducted a PLS analysis which includes only constructs of interest, and hypothesized relationship. Results are provided in Table 5A. This basic model, however, does not take into account control variables that may potentially account for some of the significant relationships. Hence, we conducted a second analysis, which included all control variables. Results are provided in Table 5B. We observe that all results for our hypotheses remain unchanged when we included the control variables into the analysis. One exception is the association between IT applications development centralization and the use of EA standards for application integration, which became insignificant with the addition of control variables. We thus interpreted the results based on Table 5B, to ensure that our results hold regardless of

whether we are considering only the key constructs of our research model or whether we include control variables in our analysis. Results of the final PLS model are summarized in Figure 4. [6]

Tables 5A and 5B and Figure 4 About Here

We tested hypotheses 1a-1d by examining the extent to which various governance mechanisms affected the use of EA standards for different IT resources. Results of the analyses only partially support our hypotheses. First, H1a states that organizations with well-defined integrating roles and architecture teams are likely to see greater use of and conformance to EA standards. H1a is supported only for EA standards to integrate business applications (H1a, path coefficient = 0.37, $p<0.10$). Second, H1b states that organizations with mechanisms facilitating the involvement of stakeholders are likely to see greater use of and conformance to EA standards. This hypothesis was not supported for all four types of EA standards. Third, H1c states that organizations with mechanisms for monitoring standards setting and conformance are more likely to see greater use of EA standards. We found that H1c holds true only for EA standards for physical IT infrastructure (H1c, $\beta = 0.41$, $p<0.05$). Finally, H1d states that organizations with centralized IT decision making are more likely to see greater use of EA standards. We found this hypothesis to be true for the use of EA standards for physical IT infrastructure (H1d, $\beta = 0.25$, $p<0.10$), for human IT infrastructure (H1d, $\beta = 0.33$, $p<0.05$), and for integrating enterprise data (H1d, $\beta = 0.44$, $p<0.001$).

Hypotheses 2a-2d were tested by examining the extent to which EA standards use resulted in better management of each type of IT resource. Our results showed that the use of EA standards had a significant effect on reducing heterogeneity of IT infrastructure components (H2a, $\beta = -0.35$, $p<0.01$), on reducing replication of IT services across business units (H2b, $\beta = -0.38$, $p<0.01$), on better integrating business applications (H2c, $\beta = 0.33$ $p<0.01$), and on better integrating enterprise data (H2d, $\beta = 0.27$, $p<0.05$). These results provide support for H2a–H2d, providing empirical evidence that the use of EA standards do provide the expected benefits of improving the sharing and integration of IT resources. The relative effect sizes of the

[6] We conducted a power analysis according to MacCallum, Browne and Sugawara [52] and Haenlein and Kaplan [35], and we found that both models presented in Tables 5A and 5B provide sufficiently high power levels (>0.80).

coefficients also suggest that EA standards have the most significant impact on managing physical and human IT infrastructure, followed by application integration, and finally enterprise data integration.

## 5. DISCUSSION

Our empirical results show that the use of EA standards helps organizations to manage their IT infrastructure, applications, and data resources. We also found that each type of governance mechanism had a different impact on the four types of EA standards. This implies that each type of EA standard needs to be managed differently, due to the characteristics of the IT resources to be managed. First, EA standards for IT infrastructure affect day-to-day operations of the IT department and have only indirect impacts on users of business units. Hence, use of these standards is most significantly associated with centralization of IT infrastructure management and institutionalization of processes to control and monitor standards setting and conformance. On the other hand, EA standards for integrating business applications are more complex to manage and require more business involvement. Thus, it is important to clearly define key architectural roles to ensure the involvement of business units and of architects with the necessary expertise to set and implement a feasible set of EA standards. Finally, we found that using EA standards for data integration is such a difficult problem that only centralization of IT application development and planning had a significant effect on the use of the EA standards. In fact, stakeholder involvement was negatively (although not significantly) associated with the use of EA data standards, which highlights how difficult it is for stakeholders in enterprise data standardization to come to an agreement. Table 6 provides a summary of the different types of governance mechanisms and how they affect the use of different EA standards. In the following sections, we discuss the results relating to the use of EA standards to manage each type of IT resource.

Table 6 About Here

### 5.1 EA Standards for Physical and Human IT Infrastructure

In our study, the use of EA standards for physical IT infrastructure was affected most significantly by whether organizations had institutionalized monitoring processes for setting and using EA standards

(H1c) and whether the IT infrastructure management of the organization was centralized in the corporate IT group (H1d). The use of EA standards for human IT infrastructure, on the other hand, was significantly associated only with the centralization of IT infrastructure management.

Different business units within the organization usually require the same infrastructure components and services [10]. There is thus less of a need for deep business insights from individual business units and more of a need for the organization's generic IT capabilities to be applied uniformly and consistently to the management of infrastructure architecture. The primary stakeholders for IT infrastructure management are the IT personnel. Users and managers from business units play a more secondary role. Hence, having a centralized corporate IT department that can easily make all decisions regarding infrastructure investments is important to facilitate the use of EA standards for both physical and human IT infrastructure.

The domain of IT infrastructure is computers, networks, routers, servers, operating systems, database management systems, and other middleware. These are commodity parts, and the goal of EA standards is to ensure the consistent purchase, use, and integration of these components across the enterprise. Conformance mechanisms can be more easily institutionalized and monitored to ensure conformance to EA standards relating to the management of such commodity parts. Furthermore, there are many external IT standards governing these components, and compliance to these external standards is important to guarantee the long-term viability of the EA standards [18, 19]. It is important for the architecture team to determine which external standards are relevant for the enterprise and incorporate them into the enterprise's IT infrastructure standards.

In terms of outcomes, our results show that the use of EA standards have a significant effect on reducing the heterogeneity of IT infrastructure components. Standardizing physical IT infrastructure components is usually the first step organizations take in coordinating the management of IT resources across business units, as establishing interconnectivity in IT infrastructure components forms the foundation for all subsequent integration [57]. Having a high level of top management support also plays a significant role in reducing the extent of heterogeneity of IT infrastructure components. This provides another indication that the standardization of IT infrastructure depends significantly on the extent of

authority the top management provides to the relevant personnel to impose monitoring controls across business units. Organizations in the banking and insurance industry also appeared to have a higher level of infrastructure heterogeneity, which may be a result of mergers between financial institutions [77].

For human IT infrastructure, our results show that the use of EA standards reduces replication of IT services across business units. Both the centralization of IT infrastructure management and the years of architecture experience also reduce replication of IT services, likely because both factors enable organizations to organize their human resources and keep track of their IT skills more efficiently.

### 5.2 EA Standards for Integrating Business Applications

Establishing interoperability through the integration of business applications is a time-consuming, resource-intensive, complex undertaking for organizations [57, 74]. Our results suggest that the key to facilitating the use of standards for integrating business applications is to identify key managerial integrating roles and to have dedicated architecture teams that provide accountability for the architecture work and have requisite skills to setting EA standards for application integration. Integrating roles are important because enterprise integration architecture concerns the integration of application systems, which tend to be more specific to individual business units. Therefore, management of integration standards needs to take into account specific requirements of each business unit and requires input from line management members who are knowledgeable about the strategy, functions, data, and environment of each business unit. Involving representatives from individual business units enables them to provide guidance about key applications critical to the organization, how the applications relate to one another, and how they are installed or developed [92]. Architecture teams are also important because integrating business applications requires detailed technical knowledge about applications that span individual responsibilities and business units. It is thus important to assemble technical resources that can harvest knowledge about integration requirements and technical capabilities about each individual application, to enable a feasible integration plan that meets business needs. As this knowledge cannot be found in any single individual or unit, it is thus important to create architecture teams.

As EA standards for integrating business applications are more focused on internal business needs and are much less dependent on external industry standards, having processes to monitor external standards is much less important. Having processes to monitor standards conformance also has a limited impact on the work of the new applications development project teams. Funding for these teams typically comes from business units [78], and the high level of independence may make it difficult to impose any standards conformance mechanisms on these teams. Stakeholder involvement through liaisons and formal mechanisms also did not have a significant effect on the use of EA standards for integrating business applications. This is likely because stronger forms of horizontal coordination are required for more complex coordination [24]; and coordination is more complex when using EA standards to integrate business applications due to the need to conduct problem analysis and solution identification, compared to using EA standards to manage IT infrastructure. Surprisingly, the centralization of IT applications planning and development did not have a significant effect on the use of EA standard to improve business applications integration, although it is only marginally insignificant. This implies that it is more important to obtain the buy-in and inputs of the senior management representatives of the business units by defining key architecture roles than to centralize IT applications development.

In terms of outcomes, our results show that the use of EA standards had a significant effect on the integration of business applications across the enterprise. Among the control variables, problems with legacy systems was a significant impediment to the use of the standards and to business applications integration, which is in line with prior research [e.g. 38, 59, 80]. In addition, the number of years of architecture experience was also significantly associated with EA standards use for business applications integration.

### 5.3 EA Standards for Integrating Enterprise Data

The use of EA standards for enterprise data integration was significantly associated with the centralization of IT systems development. Past studies have generally agreed that while data integration will potentially bring substantial benefits to organizations if they are successful in their attempts, firms that have attempted standardization have frequently failed or experienced major difficulties [33, 94]. A key problem is the difficulty in agreeing on a set of data elements that have semantically similar meanings to all units, as

each unit has unique data requirements to align itself with its localized environment. Other problems include the broad scopes of the data standardization efforts and difficulties non-technical people have in comprehending data models [23, 31, 32]. Our results reinforce the findings of prior research that rationalization of data elements is a difficult problem and that involving more stakeholders creates a wider scope for the data model, thereby making it more difficult to drive consensus around an EA data standard. The challenge of integrating data appears to be so significant that even defining integrating managerial roles and setting aside dedicated architecture resources are not sufficient to lead to a significantly higher extent of use of the standards. Only centralizing IT application development significantly facilitates the use of EA data standards; this is consistent with prior studies that have found that organizations with centralized IT decision making have a greater degree of success in data resource management [42].

Our results show that the use of EA standards has a significant effect on the outcome of standardizing data elements across the enterprise. This implies that if organizations are able to achieve adequate standards use and conformance, beneficial impacts to the integration of enterprise data will occur. However, the effect size and significance of the association between the use of EA data standards and data integration are lower than the association between EA standards use and the management of all other IT resources. This result further highlights the difficulties in achieving semantic consistency across an enterprise [57, 74], especially compared to standardizing the use of other IT resources. Among the control variables, having problems with legacy systems was a significant impediment to the use of EA data standards. The number of years of architecture experience and the importance given to standardizing data elements across the enterprise were both significantly associated with the use of EA data standards. This implies that those organizations that have decided that the standardization approach for data management is the appropriate choice and those with more experience with EA see significantly greater use of EA data standards.

## 6. CONCLUSION

In this paper, we set out to examine two key research questions: (1) How do different governance mechanisms affect the use of EA standards? and (2) To what extent does the use of EA standards enable

organizations to improve the sharing and integration of IT resources in the organization? To answer the first research question, we drew on management theories identifying different types of horizontal IT governance mechanisms [e.g., 11, 56] and applied these theories to the problem of using EA standards. We mapped the EA governance mechanisms discussed in the practitioner literature [40, 88] to the following categories of horizontal IT governance mechanisms [11, 68]: (1) defining key architecture roles; (2) involving key stakeholders through liaison roles and direct communication; (3) institutionalizing monitoring processes for setting and using EA standards; and (4) centralizing IT decision making. We hypothesized that organizations that have these IT governance mechanisms are more likely to see greater use of EA standards. Our results showed that each type of governance mechanism had a different impact on each type of EA standards.

Standards for physical and human IT infrastructure predominantly affect a technical work domain, thus it is more important to centralize IT infrastructure management to facilitate the use of these EA standards (H1d). To facilitate the use of EA standards for physical IT infrastructure, more mechanistic processes, such as the institutionalization of processes that monitor the setting of and conformance to the technical standards are required (H1c). Integration of business applications is more complex, and use of the EA standards require coordination across business units through defined architecture roles (H1a). Finally, managing EA standards for enterprise data appears to be the most difficult problem, and only centralization of IT decision making had a significant impact (H1d).

To answer the second research question, we examined how the use of EA standards affected the following outcomes: (1) the heterogeneity of IT infrastructure components across business units; (2) the replication of IT services provided by different business units; (3) the integration across applications in the enterprise; and (4) the integration of enterprise data. Our empirical results showed that the use of EA standards was significant in helping organizations to effectively manage all four types of IT resources.

### 6.1 Contributions to IS research

Our study contributes to the IS literature in several ways. First, research on IT governance mechanisms for horizontal coordination of IT resources across business units has been limited [11]. Prior IS research on IT governance has focused predominantly on the issue of centralizing versus decentralizing IT decision

making [68, 78, 79]. Several studies have pointed out the need to go beyond such limited conceptualizations of IT governance mechanisms [68, 78, 79]. In this study, we explore how four different types of IT governance mechanisms affect the use of EA standards. We examine the use of various structural mechanisms, such as the definition of an architecture management team or a chief architect, to facilitate the governance of EA standards at the senior management level. In addition, we study the types of IT governance mechanisms that would facilitate EA standards use at the operational level where standards are set and their conformance is monitored. Specifically, we examine the appointment of architects, the identification and involvement of stakeholders, and the institutionalization of various monitoring processes for standards setting and standards conformance. Our results indicate that each type of IT governance mechanism has a different impact on the use of different types of EA standards. Our study highlights the need for future research to examine different types of IT governance mechanism and the differential impacts of each type of IT governance mechanism on various aspects of IT resources management.

Second, research examining the impacts of IT standards use within organizations is lacking [3]. The need for empirical verification of the impacts of using internal organizational standards is particularly salient in the case of EA standards. A significant number of research and practitioner articles highlight the potential benefits of EA, but research verifying these claims is limited. Our study addresses this gap in the literature by investigating the ability of EA to help organizations effectively manage their IT resources.

### 6.2 Implications for the Industry

The results of our study provide guidance to the industry about how EA standards affect the management of IT resources and the types of governance mechanisms that are effective in managing EA standards. The practitioner literature has generated several frameworks that provide suggestions about the types of IT governance mechanisms that organizations should put in place [e.g., 20, 40, 88]. However, prior to this research, studies that empirically examine the validity of these claims and determine if all IT governance mechanism have significant impact on the use of EA standards were limited. In this paper, we define and empirically examine the underlying mechanisms by which organizations govern the use of EA standards. All governance mechanisms examined in this study were highly correlated with one another, indicating that

organizations have followed the recommendations in the practitioner literature to implement all mechanisms concurrently. Nevertheless, our results show that some governance mechanisms were more effective than others in achieving particular EA objectives. This implies that organizations should be more discerning in their decisions to adopt IT governance mechanisms. They may wish to focus on implementing only specific types of governance mechanisms depending on the type of IT resource to be managed using EA standards.

### 6.3 Limitations and Future Research

Because we provided a benchmarking service for respondents to assess how well they were managing their EA standards, the survey tended to attract organizations interested in improving their EA standards management. Therefore, there may be a response bias among our sampled respondents toward those who are more advanced in the management of their EA standards. This bias was confirmed by our analyses of the differences between full vs. incomplete responses and early vs. late respondents: Late respondents and those who provided incomplete responses tended to have fewer years of experience in using EA standards. As a result, our sample may not be representative of the entire population of companies. On the other hand, this result shows that our survey respondents included the early adopters and advanced users of EA standards. Given that the use of EA is not very prevalent among organizations at this time, the results of this study provide an opportunity for other organizations to learn from the experiences of these early adopters.

Moreover, due to the lack of prior survey research on governance mechanisms and the management of EA standards, the items we used to measure the governance mechanisms and use of EA standards were self constructed. While the factor analysis, reliability scores, and other analyses indicate that the reliability as well as convergent and discriminant validity of the scales were satisfactory, many of the constructs only had two items. We thus recommend that future research work focus on improving these measures.

While this study focused on the implications of using EA standards for IT, EA standards also have the potential to influence other organizational outcomes. For example, EA standards can support organizational and IT flexibility and help organizations align their use of IT to business strategy and needs. Future research should therefore examine the impact of EA standards on other organizational outcomes.

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**Figure 1. Overall Research Model**

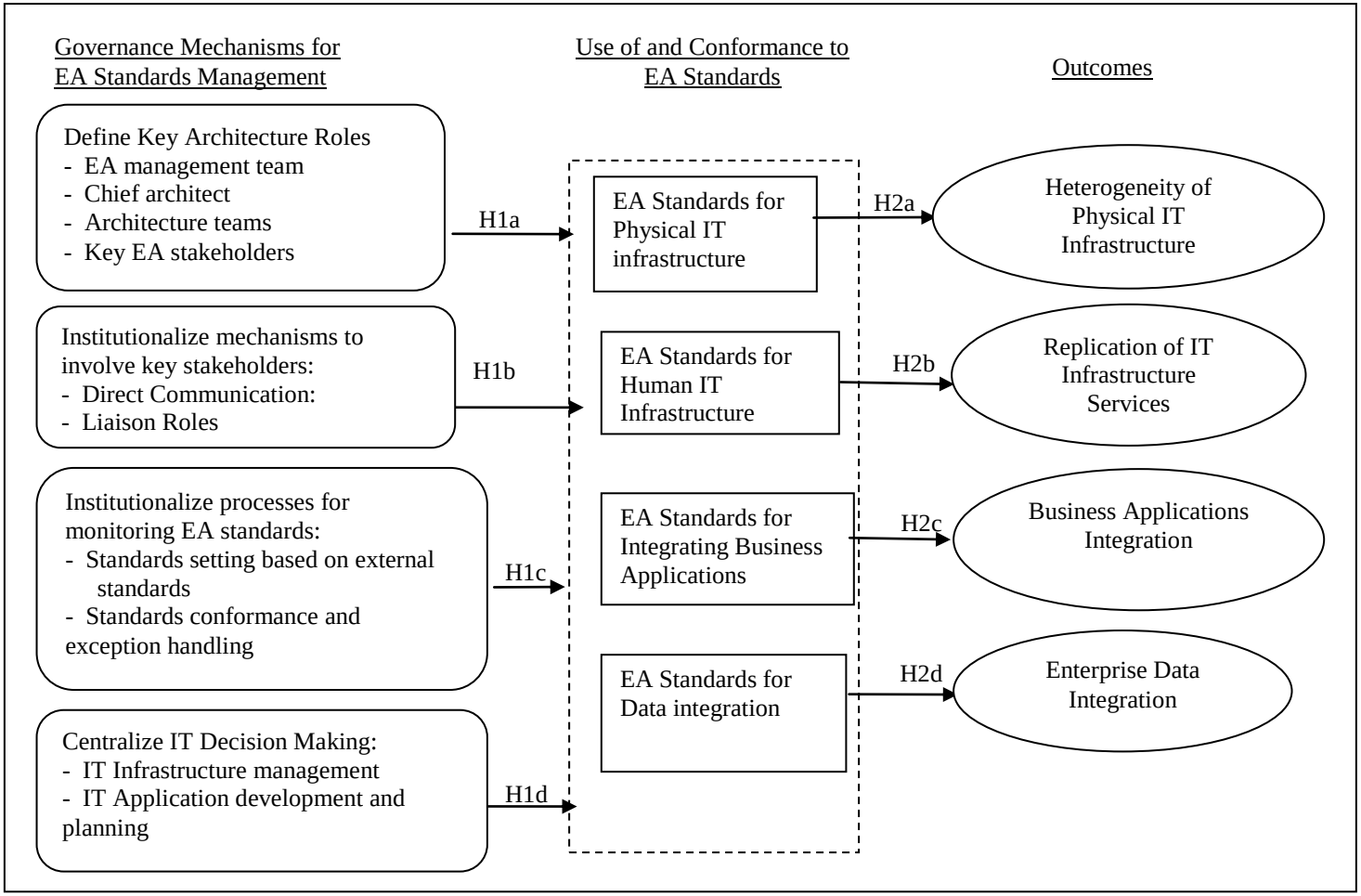


**Figure 2. Continuum of Horizontal Governance Mechanisms (adapted from Daft [22] and Brown [11])**

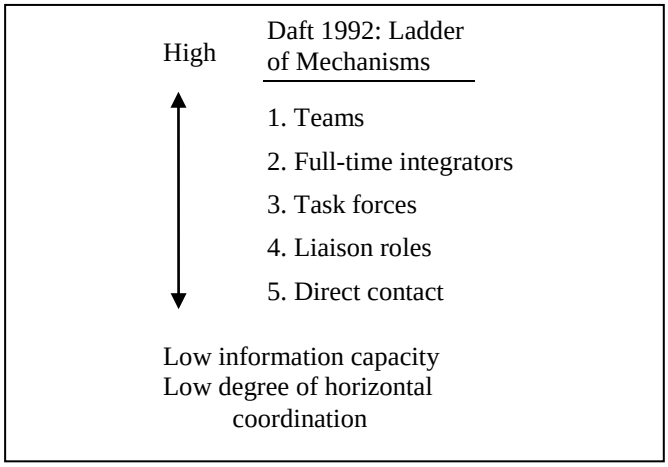



**Figure 3. Key Architecture Roles**

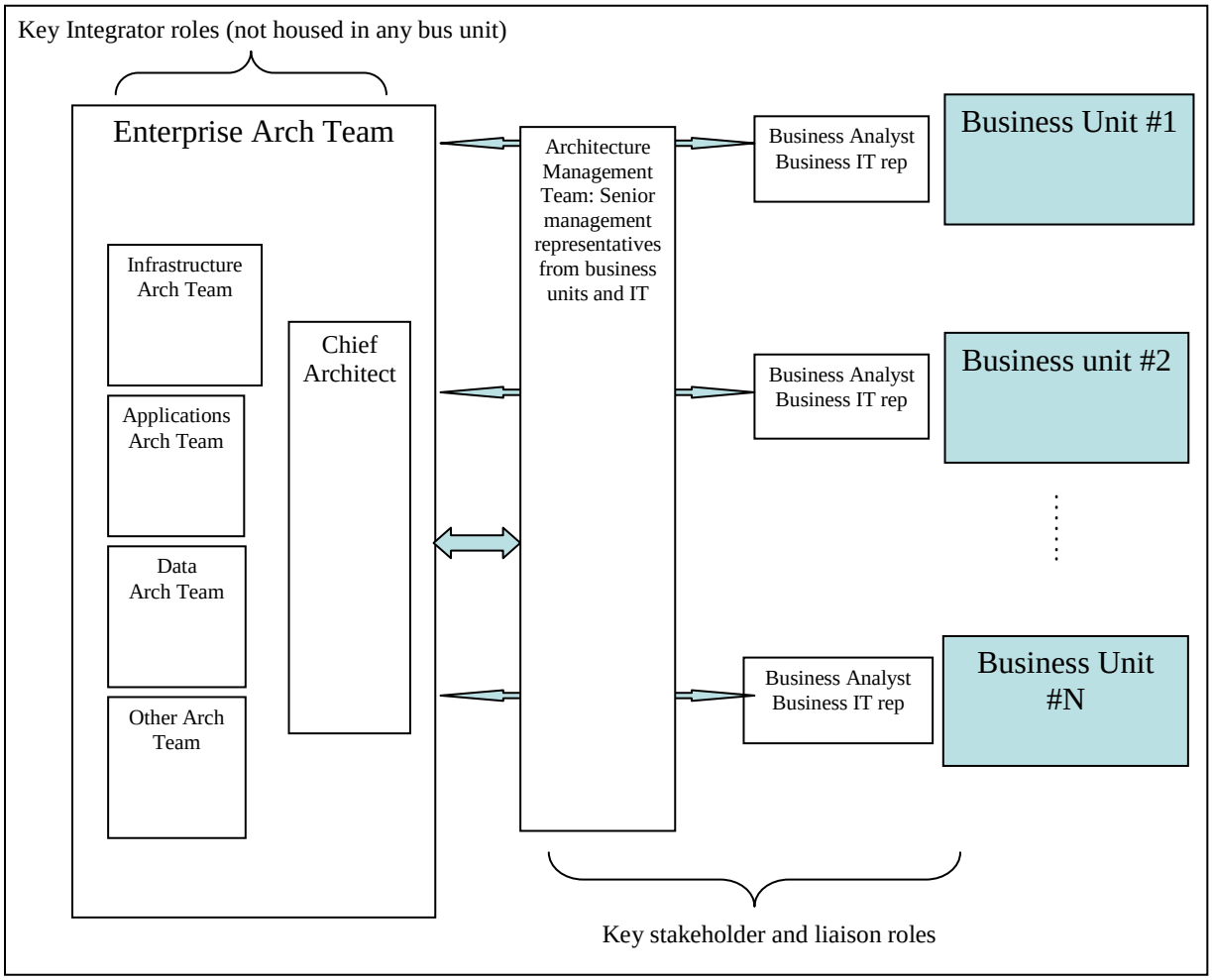
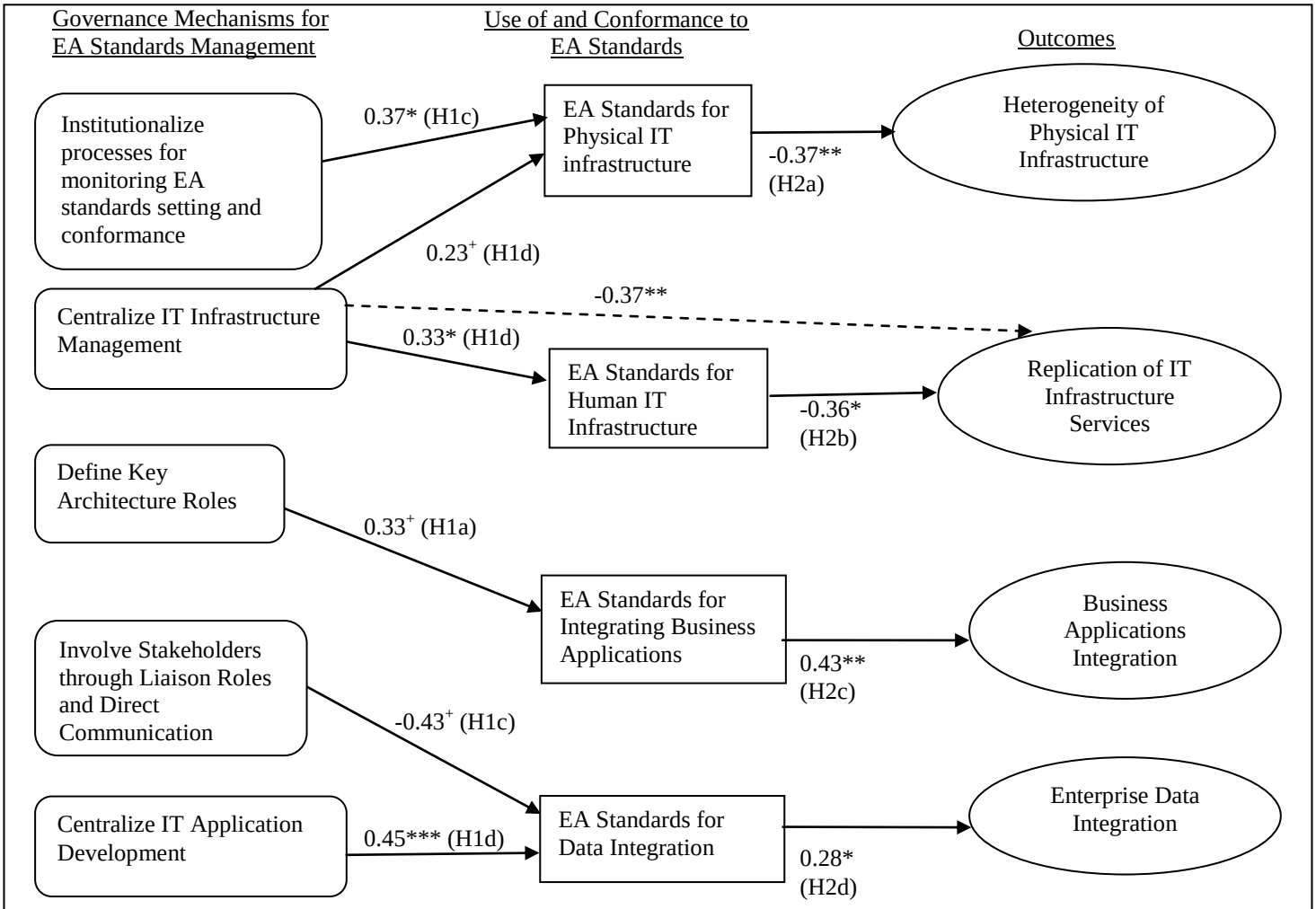


**Figure 4. Summary of Results for Hypothesis Testing**




**Additional information about results for control variables:**

| Control Variables | | Outcomes |
|---|---|---|
| Top management support | -0.29* | Heterogeneity of physical IT infrastructure |
| Banking and insurance industry | 0.28* | Heterogeneity of physical IT infrastructure |
| Years of architecture experience | -0.16+ | Replication of IT infrastructure services |
| Problems with legacy systems | -0.29* | Business applications integration |
| Problems with legacy systems | -0.32** | Enterprise data integration |
| | | **EA Standards Use** |
| Years of architecture experience | 0.26** | EA standards for physical IT infrastructure |
| Years of architecture experience | 0.17+ | EA standards for integrating business applications |
| Years of architecture experience | 0.27* | EA standards for data integration |
| Problems with legacy systems | -0.28** | EA standards for integrating business applications |
| Importance of EA objective | 0.23* | EA standards for data integration |

**Notations for significance levels (applicable to all analysis results):**

+ p<0.10, * p < .05; ** p < .01; *** p < .001

(Path coefficients are displayed in the figure, dotted arrow represents significant relationship not hypothesized.)

**Table 1. Response Rate by Sample Groups**

| Sample Group | Total No. of Organisations | No. of Respondents | Response Rate |
|---|---|---|---|
| IBM Clients | 166 | 86 | 51.8% |
| Conference Participants | 135 | 11 | 8.1% |
| Open Group Members | 170 | 11 | 6.5% |

**Table 2. Reliability of Factors**

| Construct | Number of Items | Standardized Cronbach Alpha |
|---|---|---|
| **Outcomes** | | |
| Heterogeneity of physical IT infrastructure | 3 | 0.805 |
| Replication of IT infrastructure services | 3 | 0.803 |
| Business applications integration | 2 | 0.741 |
| Enterprise data integration | 2 | 0.766 |
| **Use of and Conformance to EA Standards** | | |
| EA Standards for physical IT infrastructure | 2 | 0.750 |
| EA Standards for human IT infrastructure | 2 | 0.803 |
| EA Standards for integrating business applications | 2 | 0.788 |
| EA Standards for data integration | 2 | 0.763 |
| **Governance Mechanisms for EA Standards Management** | | |
| Define key architecture roles | 2 | 0.743 |
| Institutionalize mechanisms to involve key stakeholders | 2 | 0.817 |
| Institutionalize processes for monitoring EA standards | 2 | 0.785 |
| Centralized IT application development and planning | 2 | 0.706 |
| **Control Variables** | | |
| Top management support | 2 | 0.743 |
| Problems with legacy systems | 3 | 0.893 |
| Organization size | 2 | 0.872 |

**Table 3. PLS Variable Loadings**

| Construct | | Item No. | N | Mean | S.D. | Weight | Loading | ResidVar | Comm | Redun |
|---|---|---|---|---|---|---|---|---|---|---|
| **Outcomes** | | | | | | | | | | |
| Heterogeneity of physical IT infrastructure | | 1 | 90 | 2.550 | 1.241 | 0.337 | 0.830 | 0.311 | 0.689 | 0.227 |
| | | 2 | 90 | 2.911 | 1.260 | 0.415 | 0.853 | 0.272 | 0.728 | 0.240 |
| | | 3 | 90 | 2.678 | 1.100 | 0.427 | 0.858 | 0.264 | 0.736 | 0.243 |
| Replication of IT infrastructure services | | 1 | 89 | 3.871 | 1.228 | 0.339 | 0.786 | 0.382 | 0.618 | 0.235 |
| | | 2 | 90 | 3.356 | 1.145 | 0.450 | 0.891 | 0.207 | 0.794 | 0.302 |
| | | 3 | 90 | 3.567 | 1.281 | 0.390 | 0.854 | 0.271 | 0.729 | 0.277 |
| Business applications integration | | 1 | 86 | 2.198 | 1.452 | 0.575 | 0.875 | 0.235 | 0.765 | 0.231 |
| | | 2 | 90 | 2.683 | 0.895 | 0.561 | 0.890 | 0.208 | 0.792 | 0.239 |
| Enterprise data integration | | 1 | 90 | 2.911 | 1.167 | 0.577 | 0.908 | 0.175 | 0.825 | 0.290 |
| | | 4 | 90 | 3.178 | 1.216 | 0.534 | 0.892 | 0.204 | 0.796 | 0.279 |
| **Use of and Conformance to EA Standards** | | | | | | | | | | |
| EA Standards for physical IT infrastructure | | 1 | 89 | 2.399 | 0.613 | 0.628 | 0.914 | 0.164 | 0.836 | 0.253 |
| | | 2 | 89 | 3.472 | 1.015 | 0.495 | 0.862 | 0.257 | 0.744 | 0.225 |
| EA Standards for human IT infrastructure | | 1 | 87 | 2.333 | 0.654 | 0.540 | 0.910 | 0.172 | 0.828 | 0.377 |
| | | 2 | 85 | 3.353 | 1.192 | 0.562 | 0.908 | 0.175 | 0.825 | 0.375 |
| EA Standards for integrating business applications | | 1 | 87 | 2.144 | 0.669 | 0.628 | 0.928 | 0.140 | 0.861 | 0.290 |
| | | 2 | 86 | 2.715 | 1.152 | 0.474 | 0.880 | 0.225 | 0.775 | 0.261 |
| EA Standards for enterprise data integration | | 1 | 86 | 1.988 | 0.677 | 0.561 | 0.898 | 0.193 | 0.807 | 0.328 |
| | | 2 | 85 | 2.624 | 1.327 | 0.557 | 0.898 | 0.194 | 0.806 | 0.328 |
| **Governance Mechanisms for EA Standards Management** | | | | | | | | | | |
| Define key architecture roles | | 1 | 86 | 2.767 | 1.200 | 0.467 | 0.837 | 0.300 | 0.700 | 0.000 |
| | | 2 | 86 | 2.767 | 1.420 | 0.676 | 0.922 | 0.150 | 0.850 | 0.000 |
| Institutionalize mechanisms to involve key stakeholders | | 1 | 85 | 2.200 | 0.965 | 0.404 | 0.872 | 0.240 | 0.760 | 0.000 |
| | | 2 | 85 | 2.654 | 1.077 | 0.678 | 0.957 | 0.085 | 0.915 | 0.000 |
| Institutionalize processes for monitoring EA standards | | 1 | 85 | 2.541 | 0.964 | 0.492 | 0.885 | 0.217 | 0.783 | 0.000 |
| | | 2 | 84 | 2.648 | 1.118 | 0.613 | 0.922 | 0.150 | 0.850 | 0.000 |
| Centralized IT infrastructure mgt. | | 1 | 90 | 1.528 | 0.849 | 1.000 | 1.000 | 0.000 | 1.000 | 0.000 |
| Centralized IT application development and planning | | 1 | 90 | 2.789 | 1.309 | 0.770 | 0.958 | 0.083 | 0.917 | 0.000 |
| | | 2 | 90 | 2.444 | 1.203 | 0.344 | 0.764 | 0.417 | 0.583 | 0.000 |
| **Control Variables** | | | | | | | | | | |
| Top management support | | 1 | 89 | 2.713 | 1.105 | 0.590 | 0.904 | 0.184 | 0.817 | 0.000 |
| | | 2 | 89 | 2.511 | 1.118 | 0.531 | 0.880 | 0.226 | 0.774 | 0.000 |
| Problems with legacy systems | | 1 | 90 | 2.800 | 1.131 | 0.361 | 0.917 | 0.159 | 0.841 | 0.000 |
| | | 2 | 90 | 2.789 | 1.279 | 0.384 | 0.923 | 0.149 | 0.851 | 0.000 |
| | | 3 | 89 | 2.916 | 1.190 | 0.361 | 0.883 | 0.220 | 0.780 | 0.000 |
| Organization size | | 1 | 87 | 3.983 | 1.924 | 0.469 | 0.922 | 0.150 | 0.851 | 0.000 |
| | | 2 | 85 | 3.035 | 1.219 | 0.602 | 0.948 | 0.101 | 0.899 | 0.000 |
| Years of Arch. Experience | | 1 | 89 | 4.287 | 5.115 | 1 | 1 | 0 | 1 | 0 |
| Importance of EA objective for: | Physical IT infrastructure | 1 | 90 | 2.117 | 0.735 | 1 | 1 | 0 | 1 | 0 |
| | Human IT infrastructure | 1 | 89 | 2.219 | 0.699 | 1 | 1 | 0 | 1 | 0 |
| | Application integration | 1 | 90 | 2.000 | 0.670 | 1 | 1 | 0 | 1 | 0 |
| | Enterprise data integration | 1 | 89 | 2.225 | 0.703 | 1 | 1 | 0 | 1 | 0 |
| Banking & Insurance Industry[7] | | 1 | 90 | 0.467 | 0.502 | 1 | 1 | 0 | 1 | 0 |
| Sample from IBM Clients | | 1 | 90 | 0.889 | 0.316 | 1 | 1 | 0 | 1 | 0 |

[7] Appendix B shows that the banking and financial sector and insurance sectors made up 48.5% of all respondents. Due to the limited number of participants from each of the other sectors, we did not include controls for other sectors. We also conducted a sensitivity analysis where the banking and financial industry and insurance industry were included as two separate constructs. Our results remained the same.

## Table 4. Descriptive Statistics and Correlations Amongst Constructs

| | | Composite Reliability | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcomes | 1) Heterogeneity of physical IT infrastructure | .884 | .72 | | | | | | | | | | | | | | | | | | | | | |
| | 2) Replication of IT infrastructure services | .882 | .18 | .71 | | | | | | | | | | | | | | | | | | | | |
| | 3) Business applications integration | .875 | -.22 | -.08 | .78 | | | | | | | | | | | | | | | | | | | |
| | 4) Enterprise data integration | .895 | -.04 | .00 | .45 | .81 | | | | | | | | | | | | | | | | | | |
| Use of and Conformance to EA Standards | 5) EA Standards for physical IT infrastructure | .882 | -.37 | -.42 | .08 | .05 | .79 | | | | | | | | | | | | | | | | | |
| | 6) EA Standards for human IT infrastructure | .905 | -.16 | -.41 | .25 | .28 | .34 | .83 | | | | | | | | | | | | | | | | |
| | 7) EA Standards for integrating business applications | .900 | -.11 | -.29 | .44 | .29 | .27 | .57 | .82 | | | | | | | | | | | | | | | |
| | 8) EA Standards for data integration | .893 | -.15 | -.09 | .30 | .38 | .17 | .36 | .41 | .81 | | | | | | | | | | | | | | |
| Governance Mechanisms for EA Standards Management | 9) Define key architecture roles | .873 | -.09 | .01 | .19 | .04 | .31 | .46 | .34 | .17 | .78 | | | | | | | | | | | | | |
| | 10) Institutionalize mechanisms to involve key stakeholders | .911 | -.01 | .03 | .15 | .18 | .30 | .45 | .24 | .07 | .68 | .84 | | | | | | | | | | | | |
| | 11) Institutionalize processes for monitoring EA standards | .899 | -.05 | .10 | .09 | .08 | .36 | .39 | .22 | .09 | .61 | .84 | .82 | | | | | | | | | | | |
| | 12) Centralized IT infrastructure mgt. | NA | -.25 | -.47 | .15 | .02 | .32 | .43 | .39 | .35 | .18 | .07 | .06 | NA | | | | | | | | | | |
| | 13) Centralized IT application development and planning | .856 | -.13 | -.23 | .14 | .17 | .21 | .20 | .25 | .46 | -.03 | -.03 | .00 | .44 | .75 | | | | | | | | | |
| Control Variables | 14) Top management support | .886 | -.27 | -.19 | .27 | .30 | .29 | .41 | .30 | .27 | .38 | .44 | .35 | .27 | .24 | .80 | | | | | | | | |
| | 15) Problems with legacy systems | .933 | .02 | .15 | -.39 | -.44 | -.23 | -.35 | -.38 | -.27 | -.10 | -.24 | -.20 | -.24 | -.26 | -.26 | .82 | | | | | | | |
| | 16) Years of architecture experience | NA | -.19 | -.21 | .10 | .27 | .34 | .26 | .29 | .33 | .22 | .33 | .23 | .09 | .08 | -.31 | -.19 | NA | | | | | | |
| | 17) Organizational size | .933 | .01 | .15 | .00 | -.01 | .05 | .14 | .14 | .03 | .40 | .33 | .32 | -.27 | -.34 | -.02 | -.03 | .19 | .88 | | | | | |
| | 18) Importance of physical IT infrastructure EA objective | NA | -.13 | -.04 | .21 | .02 | .09 | .35 | .21 | .12 | .34 | .25 | .17 | .20 | .07 | .32 | -.24 | .06 | .20 | 1.00 | | | | |
| | 19) Importance of human IT infrastructure EA objective | NA | .03 | .04 | .11 | .11 | -.01 | .32 | .25 | .05 | .40 | .43 | .35 | .18 | .08 | .18 | -.10 | .05 | .16 | .39 | NA | | | |
| | 20) Importance of application integration EA objective | NA | .30 | .03 | -.03 | .15 | -.07 | .13 | .07 | .17 | .10 | .18 | .15 | -.10 | .11 | .18 | -.17 | -.01 | -.10 | .27 | .05 | NA | | |
| | 21) Importance of enterprise data integration EA objective | NA | .17 | -.03 | .04 | .23 | -.13 | .25 | .07 | .19 | .19 | .25 | .10 | .12 | .02 | .20 | -.09 | .07 | -.12 | .23 | .30 | .41 | NA | |
| | 22) Banking and insurance industry | NA | .22 | -.05 | .07 | .15 | .12 | .22 | .24 | .19 | .13 | .17 | .23 | .02 | .06 | .22 | -.12 | .02 | .05 | -.06 | -.05 | .10 | .04 | NA |
| | 23) Respondents from IBM clients | NA | -.09 | .06 | .10 | .14 | .18 | .05 | .11 | .11 | .20 | .33 | .38 | .03 | .17 | .18 | -.11 | .08 | .23 | .09 | .19 | .05 | .09 | .19 |

## Table 5A. Results of PLS Analysis for only Hypothesized Relationships

| Independent Variables | | Dependent Variables: Heterogeneity of Physical IT Infrastructure – Standards Use | Heterogeneity of Physical IT Infrastructure – Extent of Heterogeneity | Replication of IT Infrastructure Services – Standards Use | Replication of IT Infrastructure Services – Extent of Replication | Business Applications Integration – Standards Use | Business Applications Integration – Extent of Application Integration | Enterprise Data Integration – Standards Use | Enterprise Data Integration – Extent of Data Integration |
|---|---|---|---|---|---|---|---|---|---|
| Extent of Use and Conformance to EA Standards | | | -0.37*** (0.08) | | -0.41*** (0.10) | | 0.44*** (0.07) | | 0.38*** (0.09) |
| Governance Mechanisms for EA Standards Management | Define key architecture roles | 0.11 (0.13) | | 0.18 (0.13) | | 0.34* (0.14) | | 0.24 (0.15) | |
| | Institutionalize mechanisms to involve key stakeholders | -0.09 (0.21) | | 0.28 (0.20) | | 0.04 (0.19) | | -0.11 (0.21) | |
| | Institutionalize processes for monitoring EA standards | 0.36+ (0.19) | | 0.02 (0.20) | | -0.03 (0.21) | | 0.02 (0.20) | |
| | Centralized IT infrastructure mgt. | 0.29* (0.14) | | 0.37** (0.12) | | | | | |
| | Centralized IT application development and planning | | | | | 0.26* (0.10) | | 0.46*** (0.08) | |
| | R-Square | 0.139 | 0.233 | 0.380 | 0.276 | 0.181 | 0.196 | 0.246 | 0.146 |

Numbers in parentheses represent the standard errors of the estimated coefficients.

## Table 5B. Results of PLS Analysis including Control Variables[8]

| Independent Variables | | Dependent Variables: Heterogeneity of Physical IT Infrastructure – Standards Use | Heterogeneity of Physical IT Infrastructure – Extent of Infrastructure Heterogeneity | Replication of IT Infrastructure Services – Standards Use | Replication of IT Infrastructure Services – Extent of IT Services Replication | Business Applications Integration – Standards Use | Business Applications Integration – Extent of Application Integration | Enterprise Data Integration – Standards Use | Enterprise Data Integration – Extent of Data Integration |
|---|---|---|---|---|---|---|---|---|---|
| Extent of Use and Conformance to EA Standards | | | **-0.37** (0.13)** | | **-0.36* (0.15)** | | **0.34** (0.12)** | | **0.28* (0.14)** |
| Governance Mechanisms for EA Standards Management | Define key architecture roles | **0.16 (0.14)** | 0.01 (0.17) | **0.13 (0.17)** | 0.21 (0.14) | **0.33+ (0.19)** | 0.10 (0.18) | **0.16 (0.17)** | -0.19 (0.14) |
| | Institutionalize mechanisms to involve key stakeholders | **-0.25 (0.21)** | 0.02 (0.24) | **0.12 (0.21)** | 0.24 (0.23) | **-0.14 (0.27)** | 0.06 (0.32) | **-0.43 (0.26)** | 0.26 (0.22) |
| | Institutionalize processes for monitoring EA standards | **0.37+ (0.20)** | 0.26 (0.22) | **0.09 (0.23)** | -0.32 (0.22) | **-0.04 (0.24)** | -0.15 (0.26) | **0.17 (0.22)** | -0.21 (0.20) |
| | Centralized IT infrastructure mgt. | **0.23+ (0.13)** | -0.12 (0.13) | **0.33* (0.14)** | -0.37** (0.12) | | | | |
| | Centralized IT application development and planning | | | | | **0.18 (0.11)** | -0.06 (0.15) | **0.45*** (0.11)** | -0.10 (0.14) |
| Control Variables | Top management support | 0.06 (0.13) | -0.29* (0.13) | 0.15 (0.11) | -0.03 (0.14) | 0.05 (0.13) | 0.14 (0.14) | 0.08 (0.12) | 0.12 (0.12) |
| | Problems with legacy systems | -0.09 (0.13) | -0.10 (0.11) | -0.17 (0.12) | -0.07 (0.12) | -0.28** (0.11) | -0.29* (0.14) | -0.11 (0.11) | -0.32** (0.10) |
| | Years of architecture experience | 0.26** (0.09) | -0.03 (0.11) | 0.05 (0.09) | -0.16+ (0.09) | 0.17+ (0.10) | -0.09 (0.10) | 0.27* (0.11) | 0.08 (0.11) |
| | Organizational size | -0.04 (0.12) | -0.08 (0.14) | 0.12 (0.19) | 0.04 (0.13) | 0.08 (0.16) | -0.10 (0.17) | 0.19 (0.15) | -0.03 (0.13) |
| | Importance of EA objective | -0.06 (0.15) | -0.01 (0.12) | 0.09 (0.11) | 0.13 (0.11) | -0.02 (0.13) | -0.12 (0.09) | 0.23* (0.11) | 0.09 (0.10) |
| | Banking and insurance industry | | 0.28* (0.11) | | 0.03 (0.11) | 0.17 (0.11) | -0.05 (0.10) | | 0.05 (0.10) |
| | Respondents from IBM clients | 0.05 (0.08) | -0.12 (0.10) | -0.15 (0.11) | 0.06 (0.08) | -0.02 (0.15) | 0.07 (0.11) | -0.03 (0.11) | 0.08 (0.10) |
| R-Square | | 0.303 | 0.330 | 0.455 | 0.380 | 0.337 | 0.302 | 0.407 | 0.351 |

Numbers in parentheses represent the standard errors of the estimated coefficients.

[8] We also conducted additional sensitivity analysis to examine if our results would continue to hold if we dropped all non-significant, non-hypothesized relationships which had been included as controls based on Table 5B. The results remain unchanged.

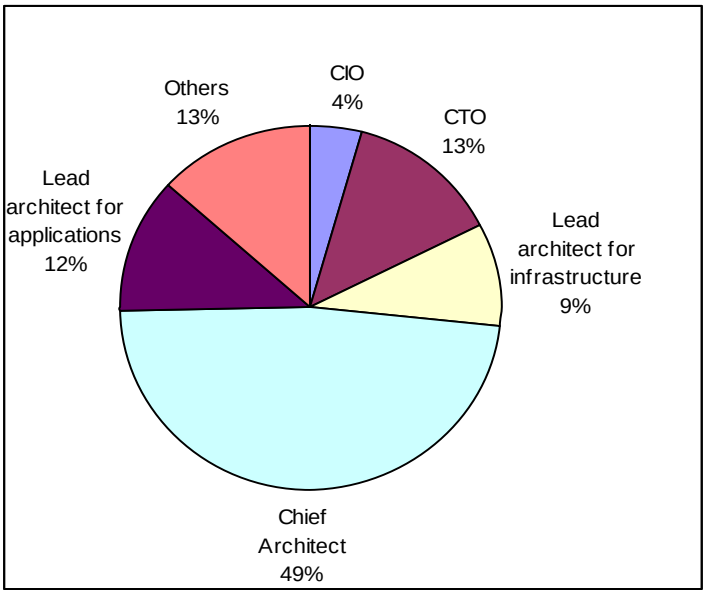
**Table 6. Summary of Governance Mechanisms for EA Standards Management and How They Affect the Use of EA Standards**

| | **Define Key Architecture Roles (H1a)** | **Institutionalize Mechanisms to Involve Key Stakeholders (H1b)** | **Institutionalize Monitoring Processes for EA standards (H1c)** | **Centralize IT Decision Making (H1d)** |
|---|---|---|---|---|
| **Key Aspects** | Specific roles identified:<br>1. Architecture Management Team<br>2. Chief Architect<br>3. Architecture Teams<br>4. Key Stakeholders | Stakeholder involvement through:<br>1. Business analysts<br>2. Formal mechanisms to facilitate direct contact between architects and stakeholders | Processes to monitor:<br>1. Standards setting based on external standards<br>2. Standards conformance | Centralization of:<br>1. IT infrastructure management<br>2. IT application planning and development |
| **Significant Results:** | Positive association with use of EA standards for integrating business applications | NIL | Positive association with use of EA standards for reducing heterogeneity of physical IT infrastructure components | Positive association with use of EA standards for:<br>1. Reducing heterogeneity of physical IT infrastructure components<br>2. Reducing replication of human IT infrastructure services<br>3. Integrating enterprise data |

## Appendix A. Profile of survey respondents

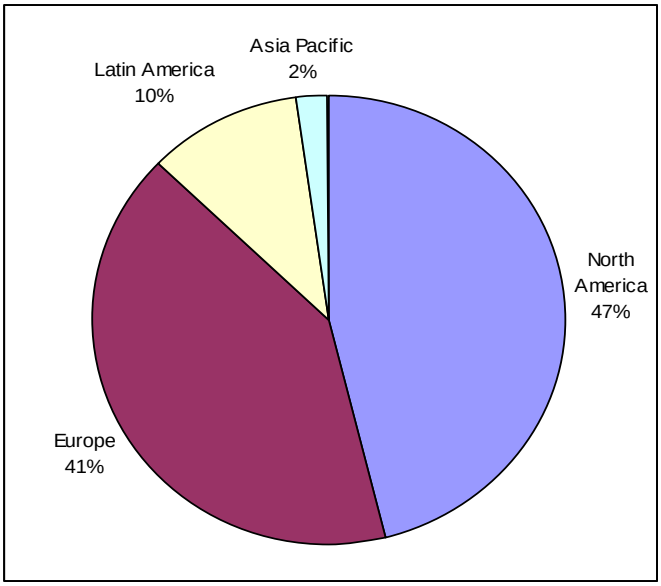
This appendix provides more details about the profile of the 90 respondents participating in this survey.

### Roles of Respondents



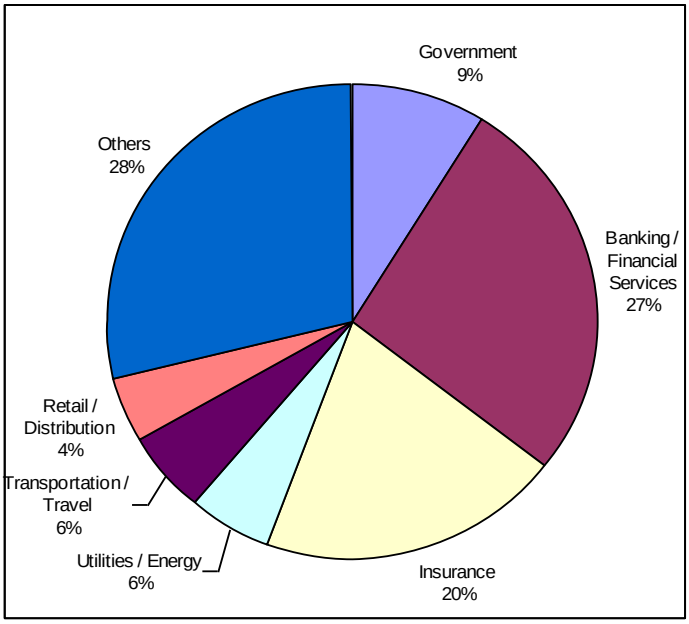

The above pie chart shows that most of our respondents are chief architects, or the lead architect for the application or infrastructure areas for the organization.

### Geographic Location of Respondents



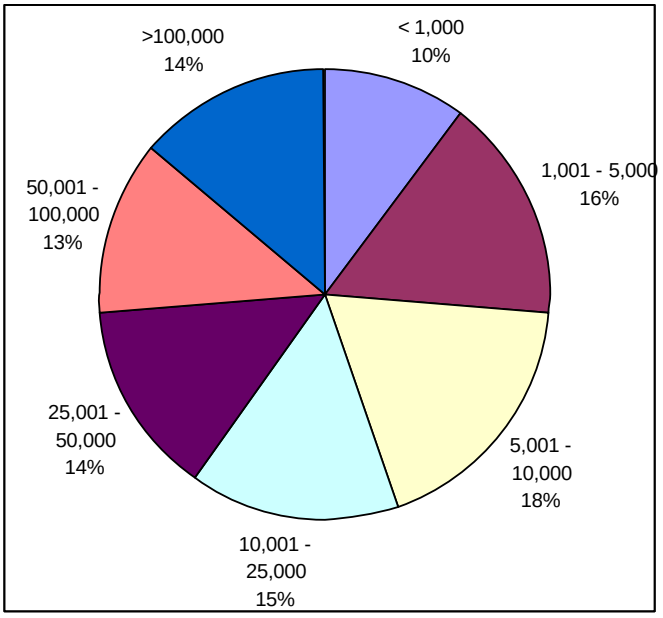

The above pie chart shows that most of our respondents are headquartered either in North America or Europe.

### Industry Breakdown of Respondents




The other sector includes manufacturing, electronics, health care, aerospace and defence, education, media and entertainment, and networks and telecommunications.

### Organization Size of Respondents




The above chart shows that the organization size of our respondents is well distributed across the spectrum.

## Appendix B. Constructs, measurement scaling and sources, and items

| Construct | Type of Scale | Sources | Items |
|---|---|---|---|
| **Governance Mechanisms for EA Standards Management** | | | |
| Define key architecture roles | Select all that apply | [20] | To Measure Number of Architecture Roles:<br><br>Please indicate which of the following architecture roles are defined in your company:<br>1) **Architecture leader / Chief Architect**: Other than the CTO/CIO, the primary individual responsible for defining, and leading the definition of the EA, and its relevance to both technology and the rest of the enterprise.<br>2) **Architecture Team**: A team of individuals whose primary job responsibilities is to define and manage information technology architecture in the company.<br>3) **Architecture Management Team**: A governance body who has responsibility for providing guidance and direction to the architecture team, and making high-level decisions regarding the EA.<br>4) **Architecture Stakeholders:** Representatives from business groups or IT groups affected by the architecture, who are invited to provide inputs to the architecture setting and management process.<br>5) **Other:** Please specify |
| | Select all that apply | | To Measure Number of Architecture Teams:<br><br>If your company has an architecture team, please identify the key architecture teams in your company and indicate which of the following architecture teams exist in your company:<br>1) **Infrastructure Architecture team**: Responsible for IT infrastructure architecture.<br>2) **Application Architecture team**: Responsible for defining the structure for individual business applications and the means by which business services and information is defined and accessed by the enterprise.<br>3) **Information Management Architecture team**: Responsible for defining and managing the enterprise data model.<br>4) **Business Architecture team**: Responsible for defining and managing the enterprise business process model.<br>5) **Other:** Please specify |
| Institutionalize mechanisms to involve key stakeholders [9] | Scale:<br>1) No processes used<br>2) Ad-hoc mechanisms used<br>3) Formal processes defined, but use of processes is not monitored<br>4) Formal processes defined, and use of processes is monitored | | To Measure Stakeholder Involvement through Formal Processes:<br><br>Please rate the extent to which each of the following architecture teams has in place <u>defined processes</u> to ensure adequate stakeholder representation in the standards setting, changing and communication process (averaged across all groups):<br>1) Infrastructure Architecture team<br>2) Application Architecture team<br>3) Information Management Architecture team<br>4) Business Architecture team<br>5) Other |

[9] We conducted sensitivity analysis to examine how our results would change if the measures for governance mechanisms did not take into account the "Other" architecture team. Our results remain unchanged.

| Construct | Type of Scale | Sources | Items |
|---|---|---|---|
| | Scale:<br>1) Work within the arch. group<br>2) Work closely with the arch. group<br>3) Work occasionally with the arch. group<br>4) Do not work with the arch. group | | To Measure Stakeholder Involvement through Business Analysts:<br><br>For each architecture team, please indicate how closely each architecture team works with business analysts (averaged across all groups):<br>1) Infrastructure Architecture team<br>2) Application Architecture team<br>3) Information Management Architecture team<br>4) Business Architecture team<br>5) Other |
| Institutionalize processes for monitoring EA standards [10] | Scale:<br>1) Internal standards are constantly updated based on external standards<br>2) Internal standards are frequently influenced by external standards<br>3) Internal standards are somewhat influenced by external standards<br>4) Internal standards are not influenced by external standards | | To Measure Extent of Standards Setting Based on External Standards:<br><br>For each architecture team, please indicate the extent to which the architecture work by each architecture team is influenced by and kept up to date with external industry standards (averaged across all groups).<br>1) Infrastructure Architecture team<br>2) Application Architecture team<br>3) Information Management Architecture team<br>4) Business Architecture team<br>5) Other |
| | Scale:<br>1) No processes used<br>2) Ad-hoc mechanisms used<br>3) Formal processes defined, but use of processes is not monitored<br>4) Formal processes defined, and use of processes is monitored | | To Measure Extent of Formal Processes for Standards Conformance and Exception Handling:<br><br>Please rate the extent to which each architecture team has in place defined processes to ensure adequate conformance and designated means to consider exceptions to standards conformance.(averaged across all groups):<br>1) Infrastructure Architecture team<br>2) Application Architecture team<br>3) Information Management Architecture team<br>4) Business Architecture team<br>5) Other |
| Centralize IT Decision-Making | 5-point scale; bounded by:<br>Centralized in Corporate IT Group / Decentralized in Lines of Business | [46, 64] | To Measure Extent of Centralization for IT Infrastructure Management:<br><br>What is the extent of centralization for the following IT services in your company?<br>(1) Infrastructure planning and management |
| | | | To Measure Extent of Centralization for IT Applications Development and Planning:<br><br>What is the extent of centralization for the following IT services in your company?<br>(2) Application development projects prioritization and approval<br>(3) IT development and implementation |

| Construct | Type of Scale | Sources | Items |
|---|---|---|---|
| **Use of and Conformance to EA Standards** | | | |
| EA standards for physical IT infrastructure | Scale:<br>1) Nearly no standards defined;<br>2) Standards defined in some aspects<br>3) Standard defined in nearly all aspects | | To Measure Extent of Standards Definition:<br><br>Please rate the extent to which your company has defined formal architecture guidelines and internal standards:<br>1) To reduce heterogeneity of infrastructure components across lines of business. |
| | 5-point scale; bounded by: very low / very high | | To Measure Extent of Standards Conformance:<br><br>Please rate the extent to which members of the company use and conform to the formal company-defined architecture guidelines and internal standards:<br>1) To reduce heterogeneity of infrastructure components across lines of business. |
| EA standards for human IT infrastructure | Scale:<br>1) Nearly no standards defined;<br>2) Standards defined in some aspects<br>3) Standard defined in nearly all aspects | | To Measure Extent of Standards Definition:<br><br>Please rate the extent to which your company has defined formal architecture guidelines and internal standards:<br>2) To reduce redundancy of infrastructure services provided by different IT groups |
| | 5-point scale; bounded by: very low / very high | | To Measure Extent of Standards Conformance:<br><br>Please rate the extent to which members of the company use and conform to the formal company-defined architecture guidelines and internal standards:<br>2) To reduce redundancy of infrastructure services provided by different IT groups. |
| EA standards for integrating business applications | Scale:<br>1) Nearly no standards defined;<br>2) Standards defined in some aspects<br>3) Standard defined in nearly all aspects | | To Measure Extent of Standards Definition:<br><br>Please rate the extent to which your company has defined formal architecture guidelines and internal standards:<br>3) To enable better integration across applications. |
| | 5-point scale; bounded by: very low / very high | | To Measure Extent of Standards Conformance:<br><br>Please rate the extent to which members of the company use and conform to the formal company-defined architecture guidelines and internal standards:<br>3) To enable better integration across applications. |
| EA standards for enterprise data integration | Scale:<br>1) Nearly no standards defined;<br>2) Standards defined in some aspects<br>3) Standard defined in nearly all aspects | | To Measure Extent of Standards Definition:<br><br>Please rate the extent to which your company has defined formal architecture guidelines and internal standards:<br>4) To enable better management of enterprise data. |
| | 5-point scale; bounded by: very low / very high | | To Measure Extent of Standards Conformance:<br><br>Please rate the extent to which members of the company use and conform to the formal company-defined architecture guidelines and internal standards:<br>4) To enable better management of enterprise data. |
| **Outcomes** | | | |
| Heterogeneity of physical IT infrastructure | 5-point scale; bounded by: strongly agree / strongly disagree | [36] | (1) There is heterogeneity in the Hardware and network components used across projects or lines of business.<br>(2) There is heterogeneity in the Middleware (including application servers and messaging brokers) used across projects or lines of business.<br>(3) There is heterogeneity in the Tools (including network management and software development tools) used across projects or lines of business. |

| Construct | Type of Scale | Sources | Items |
|---|---|---|---|
| Replication of IT infrastructure services | 5-point scale; bounded by: strongly agree / strongly disagree | [10] | (1) Multiple groups in different lines of business are providing similar security, disaster planning and business recovery services.<br>(2) Multiple groups in different lines of business are providing similar services to manage electronic linkages to suppliers or customers.<br>(3) Multiple groups in different lines of business are providing similar infrastructure services (supporting hardware and middleware). |
| Business applications integration | Q1. 5-point scale: 0-20%, 21-40%, 41-60%, 61-80%, 81-100%.<br>Q2. 5-point scale; bounded by: strongly agree / strongly disagree for Q 3. | | (1) What percentage of the key applications systems are integrated by a common middleware approach (e.g. using "integration bus/hub" or synchronous / asynchronous messaging).<br>(2) The functional boundaries of individual applications and components have been clearly defined. |
| Enterprise data integration | Q1-3: 5-point scale; bounded by: strongly agree / strongly disagree;<br>Q4: 4-point scale: 0-25%, 26-50%, 51-75%, 76-100%. | [25], [16] | (1) My company has formally and sufficiently identified data to be shared across lines of business.<br>(2) The customer entity is perceived and interpreted in a common fashion by all systems and lines of business.<br>(3) Key business performance indicators extracted from IT systems are readily available to decision makers who require the information.<br>(4) Among the set of data that the company would like to share across lines of business, what percentage of the data is currently sharable across lines of business? |
| **Control Variables** | | | |
| Top management support | 5-point scale; bounded by: strongly agree / strongly disagree | [4, 61] | To what extent do you agree with the following statements about your company (Top management in this question refers to the top executives in lines of businesses or in the corporate office):<br>(1) Top management provides sufficient resources to the architecture team.<br>(2) Top management has granted the architecture team the necessary authority concerning architecture projects and work.<br>(3) Top management views EA to be a key mechanism to align business requirements to IT development. |
| Problems with legacy systems | 5-point scale; bounded by: strongly agree / strongly disagree | | Please rate the extent to which you agree with the following statements about your company:<br>(1) Legacy systems pose a serious problem in restricting my company's ability to move towards a service-oriented architecture.<br>(2) Legacy systems pose a serious problem in restricting our ability to support business processes that span multiple applications.<br>(3) Legacy systems pose a serious problem in restricting my company's ability to provide an integrated view of enterprise data. |
| Organizational size | Q1. 7-point scale: < 1K, 1K-5K 5K-10K, 10K-25K, 25K-50K 50K-100K, >100K<br>Q2. 6-point scale:<100, 101-500, 501-1K, 1K-5K, 5K-20K, >20K | | (1) How many people are working in your company?<br>(2) How many people are working in the IT function in your company? |
| Years of architecture experience | | | If an Architecture Team exists in your company, please state the number of years that the architecture team has been formed (measured for all application groups) |
| Importance of EA objective | Scale:<br>1) Critical<br>2) High Priority<br>3) Low Priority<br>4) Not Considered | | Please indicate how your organization prioritizes each of the following architecture management objectives:<br>(1) To reduce heterogeneity of infrastructure components across lines of business<br>(2) To reduce redundancy of infrastructure services provided by different IT groups<br>(3) To enable better integration across applications<br>(4) To enable better management of enterprise data |

## Appendix C. Results of exploratory factor analysis

| Variable | Item No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heterogeneity of physical IT infrastructure | 1 | 0.87 | 0.07 | 0.00 | 0.03 | -0.01 | -0.02 | 0.05 | 0.05 | 0.12 | 0.10 | 0.00 | 0.00 | 0.08 | -0.12 |
| | 2 | 0.72 | 0.04 | 0.02 | 0.08 | 0.19 | 0.20 | -0.05 | -0.07 | -0.16 | -0.16 | -0.27 | 0.03 | 0.01 | 0.04 |
| | 3 | 0.81 | 0.08 | 0.03 | -0.05 | 0.20 | 0.15 | 0.09 | 0.05 | 0.05 | -0.10 | 0.11 | 0.00 | 0.03 | -0.08 |
| Replication of IT infrastructure services | 1 | -0.03 | 0.82 | 0.10 | -0.09 | 0.24 | 0.22 | 0.04 | 0.03 | 0.03 | 0.00 | -0.02 | 0.07 | -0.08 | -0.02 |
| | 2 | 0.17 | 0.85 | 0.01 | -0.01 | 0.04 | -0.03 | -0.03 | -0.01 | -0.01 | -0.13 | 0.00 | -0.20 | 0.03 | 0.06 |
| | 3 | 0.07 | 0.78 | 0.08 | 0.13 | 0.02 | -0.09 | -0.01 | 0.15 | -0.09 | 0.16 | -0.29 | 0.16 | 0.04 | -0.02 |
| Business application integration | 1 | -0.01 | 0.25 | 0.80 | -0.14 | -0.06 | 0.17 | 0.10 | -0.08 | 0.14 | -0.03 | 0.06 | -0.12 | 0.17 | -0.06 |
| | 2 | 0.05 | 0.04 | 0.77 | -0.20 | 0.00 | -0.09 | -0.02 | 0.31 | 0.01 | 0.14 | -0.17 | -0.05 | 0.24 | -0.01 |
| Enterprise data integration | 1 | 0.05 | 0.01 | -0.15 | 0.78 | -0.05 | 0.07 | -0.12 | -0.23 | -0.11 | -0.16 | 0.20 | 0.05 | -0.22 | 0.07 |
| | 4 | 0.04 | -0.02 | -0.20 | 0.75 | 0.04 | -0.21 | 0.08 | -0.08 | 0.01 | 0.11 | 0.04 | 0.01 | -0.28 | 0.00 |
| | 2 | -0.09 | -0.06 | -0.17 | 0.22 | -0.08 | -0.10 | 0.58 | -0.19 | 0.12 | 0.02 | 0.31 | 0.07 | -0.42 | -0.17 |
| | 3 | 0.04 | -0.20 | 0.48 | -0.44 | 0.27 | 0.07 | -0.13 | 0.04 | -0.06 | -0.34 | -0.14 | 0.04 | 0.13 | 0.04 |
| EA Standards for physical IT infrastructure | 1 | 0.21 | 0.25 | -0.09 | 0.12 | 0.66 | 0.09 | 0.21 | 0.15 | 0.40 | -0.12 | 0.02 | 0.21 | 0.10 | -0.04 |
| | 2 | 0.30 | 0.23 | 0.08 | -0.10 | 0.81 | 0.00 | -0.15 | 0.00 | 0.10 | -0.05 | -0.13 | -0.06 | 0.13 | 0.04 |
| EA Standards for human IT infrastructure | 1 | 0.27 | 0.08 | 0.07 | -0.15 | 0.00 | 0.74 | 0.20 | 0.07 | 0.30 | -0.15 | -0.17 | 0.04 | 0.14 | 0.04 |
| | 2 | 0.32 | 0.05 | 0.09 | -0.11 | 0.11 | 0.64 | 0.01 | 0.22 | 0.28 | 0.07 | -0.07 | -0.30 | 0.18 | 0.08 |
| EA Standards for integrating business applications | 1 | 0.24 | 0.07 | 0.16 | -0.15 | -0.07 | 0.27 | 0.69 | 0.17 | 0.05 | -0.02 | -0.16 | -0.09 | 0.26 | 0.19 |
| | 2 | 0.20 | -0.05 | 0.47 | -0.01 | 0.22 | 0.25 | 0.45 | 0.29 | 0.06 | -0.10 | -0.11 | -0.25 | 0.21 | 0.12 |
| EA Standards for enterprise data integration | 1 | 0.03 | 0.14 | 0.06 | -0.29 | -0.11 | 0.19 | 0.02 | 0.72 | 0.20 | -0.34 | 0.09 | -0.01 | -0.01 | 0.16 |
| | 2 | -0.01 | 0.02 | 0.14 | -0.14 | 0.18 | 0.04 | 0.04 | 0.83 | -0.13 | -0.12 | -0.13 | -0.22 | 0.17 | -0.03 |
| Define key architecture roles | 1 | -0.20 | -0.06 | 0.08 | 0.21 | 0.25 | 0.20 | 0.31 | 0.12 | 0.48 | 0.18 | -0.38 | 0.07 | -0.12 | 0.28 |
| | 2 | -0.05 | 0.05 | 0.17 | 0.19 | 0.09 | 0.35 | 0.04 | 0.16 | 0.70 | 0.06 | -0.12 | -0.17 | 0.06 | 0.08 |
| Institutionalize mechanisms to involve key stakeholders | 1 | -0.08 | -0.03 | -0.14 | -0.12 | -0.07 | 0.07 | 0.06 | -0.11 | 0.75 | 0.02 | -0.36 | -0.06 | 0.12 | 0.10 |
| | 2 | 0.08 | 0.01 | 0.10 | -0.05 | 0.07 | 0.10 | -0.01 | 0.05 | 0.88 | 0.10 | -0.08 | -0.09 | 0.12 | 0.11 |
| Institutionalize processes for monitoring EA standards | 1 | -0.02 | -0.03 | 0.03 | -0.08 | 0.08 | 0.10 | -0.09 | -0.03 | 0.86 | -0.02 | 0.03 | 0.12 | 0.05 | 0.11 |
| | 2 | 0.18 | -0.05 | 0.01 | 0.01 | 0.06 | -0.08 | 0.18 | -0.01 | 0.84 | -0.10 | -0.06 | -0.17 | 0.06 | 0.15 |
| Centralized IT infrastructure mgt. | 1 | -0.42 | -0.17 | -0.07 | -0.21 | 0.01 | -0.30 | -0.13 | -0.45 | -0.08 | 0.09 | 0.13 | -0.16 | -0.20 | 0.34 |
| Centralized IT application development and planning | 1 | -0.01 | 0.08 | 0.13 | -0.04 | -0.20 | -0.08 | 0.02 | -0.14 | 0.06 | 0.76 | -0.05 | 0.20 | -0.19 | 0.25 |
| | 2 | -0.16 | -0.15 | -0.15 | 0.03 | 0.10 | 0.02 | -0.08 | -0.36 | -0.02 | 0.71 | 0.24 | -0.11 | -0.12 | 0.24 |
| Top management support | 1 | 0.01 | -0.21 | -0.13 | 0.23 | -0.01 | -0.19 | 0.02 | -0.03 | -0.29 | 0.09 | 0.65 | 0.11 | 0.03 | -0.04 |
| | 2 | -0.18 | -0.14 | -0.02 | 0.09 | -0.14 | -0.03 | -0.04 | -0.09 | -0.27 | 0.06 | 0.73 | 0.25 | -0.17 | 0.18 |
| | 3 | 0.06 | -0.01 | -0.18 | 0.04 | 0.07 | -0.10 | -0.06 | -0.17 | -0.22 | 0.09 | 0.26 | 0.79 | -0.10 | 0.00 |
| Problems with legacy systems | 1 | 0.05 | -0.09 | 0.17 | -0.07 | 0.02 | 0.10 | -0.06 | 0.11 | 0.13 | -0.15 | 0.00 | -0.14 | 0.86 | 0.09 |
| | 2 | -0.03 | 0.00 | 0.19 | -0.10 | 0.09 | 0.09 | 0.13 | 0.08 | 0.10 | -0.03 | -0.03 | 0.04 | 0.87 | 0.01 |
| | 3 | 0.15 | 0.08 | 0.02 | -0.29 | 0.06 | 0.01 | 0.02 | 0.00 | 0.11 | -0.07 | -0.08 | -0.02 | 0.83 | -0.11 |
| Organization size | 1 | -0.09 | 0.04 | -0.05 | 0.02 | -0.05 | 0.04 | 0.01 | 0.01 | 0.29 | 0.18 | 0.01 | 0.07 | -0.04 | 0.84 |
| | 2 | -0.09 | -0.01 | 0.01 | 0.04 | 0.05 | 0.04 | 0.07 | 0.02 | 0.19 | 0.10 | 0.04 | -0.06 | 0.07 | 0.90 |

# Appendix D. Correlation Matrix for Survey Items

| | No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heterogeneity of physical IT infrastructure | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | .52 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | .66 | .55 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Replication of ITinfrastructure services | 1 | .05 | .11 | .19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | .19 | .16 | .18 | .59 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | .12 | .16 | .04 | .56 | .59 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Business application integration | 1 | .07 | .02 | .08 | .29 | .22 | .13 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | .06 | .04 | .07 | .12 | .03 | .19 | .59 | | | | | | | | | | | | | | | | | | | | | | | | |
| Enterprise data integration | 1 | -.02 | .04 | .02 | -.06 | .00 | -.03 | -.29 | -.44 | | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | .02 | -.02 | -.03 | -.09 | -.01 | .03 | -.36 | -.37 | .62 | | | | | | | | | | | | | | | | | | | | | | |
| EA Standards for physical IT infrastructure | 1 | .27 | .24 | .36 | .36 | .20 | .24 | .02 | -.03 | .02 | .07 | | | | | | | | | | | | | | | | | | | | | |
| | 2 | .26 | .40 | .38 | .34 | .30 | .22 | .13 | .17 | -.15 | -.14 | .60 | | | | | | | | | | | | | | | | | | | | |
| EA Standards for human IT infrastructure | 1 | .29 | .34 | .37 | .22 | .13 | .05 | .29 | .09 | -.18 | -.28 | .36 | .15 | | | | | | | | | | | | | | | | | | | |
| | 2 | .29 | .28 | .34 | .15 | .17 | .03 | .24 | .25 | -.21 | -.24 | .28 | .31 | .67 | | | | | | | | | | | | | | | | | | |
| EA Standards for integrating business applications | 1 | .22 | .16 | .26 | .14 | .09 | .10 | .28 | .29 | -.26 | -.23 | .22 | .06 | .49 | .43 | | | | | | | | | | | | | | | | | |
| | 2 | .17 | .26 | .25 | .10 | .10 | .02 | .42 | .46 | -.27 | -.18 | .27 | .27 | .43 | .53 | .65 | | | | | | | | | | | | | | | | |
| EA Standards for enterprise data integration | 1 | -.01 | .01 | .17 | .20 | .14 | .04 | .16 | .24 | -.27 | -.32 | .17 | .03 | .37 | .33 | .32 | .32 | | | | | | | | | | | | | | | |
| | 2 | .06 | .07 | .08 | .10 | .11 | .10 | .16 | .42 | -.38 | -.25 | .15 | .20 | .19 | .29 | .23 | .45 | .62 | | | | | | | | | | | | | | |
| Define key architecture roles | 1 | -.05 | -.05 | -.07 | .13 | -.09 | .05 | .08 | .05 | -.05 | .11 | .35 | .11 | .36 | .17 | .24 | .25 | .06 | .10 | | | | | | | | | | | | | |
| | 2 | .10 | .00 | .06 | .18 | .05 | .02 | .27 | .15 | -.10 | -.04 | .32 | .17 | .43 | .46 | .24 | .33 | .24 | .11 | .59 | | | | | | | | | | | | |
| Institutionalize mechanisms to involve key stakeholders | 1 | .01 | -.09 | -.11 | .00 | .00 | -.06 | .01 | .02 | -.23 | -.09 | .19 | .07 | .32 | .30 | .20 | .08 | .07 | -.11 | .48 | .56 | | | | | | | | | | | |
| | 2 | .13 | -.03 | .11 | .09 | -.02 | .00 | .20 | .17 | -.19 | -.10 | .40 | .22 | .40 | .43 | .22 | .26 | .24 | -.05 | .46 | .68 | .69 | | | | | | | | | | |
| Institutionalize processes for monitoring EA standards | 1 | .03 | -.06 | .03 | .02 | -.01 | -.13 | .13 | .01 | -.15 | -.05 | .40 | .15 | .32 | .30 | .03 | .11 | .20 | -.10 | .40 | .54 | .63 | .72 | | | | | | | | | |
| | 2 | .20 | .01 | .16 | -.04 | .04 | -.08 | .12 | .02 | -.08 | .01 | .39 | .19 | .32 | .34 | .27 | .25 | .20 | -.03 | .46 | .56 | .62 | .79 | .65 | | | | | | | | |
| Centralized IT infrastructure mgt. | 1 | -.42 | -.29 | -.47 | -.17 | -.21 | -.25 | -.13 | -.16 | .00 | .05 | -.35 | -.20 | -.37 | -.42 | -.34 | -.37 | -.29 | -.34 | -.06 | -.24 | .00 | -.11 | -.01 | -.09 | | | | | | | |
| Centralized IT application development and planning | 1 | -.01 | -.16 | -.16 | .04 | -.02 | .15 | .03 | .08 | -.02 | .13 | -.18 | -.18 | -.11 | -.09 | -.04 | -.12 | -.23 | -.28 | .19 | -.03 | .08 | .10 | .08 | -.02 | .22 | | | | | | |
| | 2 | -.16 | -.26 | -.19 | -.15 | -.18 | -.17 | -.16 | -.23 | .14 | .22 | -.21 | -.11 | -.28 | -.11 | -.19 | -.30 | -.43 | -.42 | .10 | -.05 | -.03 | .01 | .02 | -.04 | .47 | .55 | | | | | |
| Top management support | 1 | -.20 | -.26 | -.20 | -.16 | -.20 | -.24 | -.17 | -.22 | .28 | .15 | -.25 | -.35 | -.32 | -.34 | -.28 | -.29 | -.16 | -.28 | -.28 | -.32 | -.41 | -.35 | -.16 | -.33 | .31 | .12 | .29 | | | | |
| | 2 | .01 | .01 | .00 | -.01 | -.10 | .03 | -.28 | -.29 | .22 | .20 | .02 | -.03 | -.23 | -.36 | -.26 | -.39 | -.20 | -.34 | -.21 | -.38 | -.27 | -.32 | -.10 | -.29 | .06 | .17 | .19 | .42 | | | |
| Problems with legacy systems | 1 | .11 | .06 | .11 | -.09 | .03 | -.07 | .32 | .32 | -.26 | -.38 | .10 | .18 | .28 | .34 | .26 | .36 | .22 | .34 | -.02 | .22 | .17 | .22 | .16 | .24 | -.20 | -.24 | -.20 | -.25 | -.27 | | |
| | 2 | .06 | .05 | .08 | .00 | .03 | .04 | .32 | .40 | -.35 | -.36 | .20 | .20 | .28 | .27 | .35 | .39 | .17 | .27 | .04 | .19 | .13 | .22 | .19 | .14 | -.18 | -.18 | -.17 | -.21 | -.16 | .80 | |
| | 3 | .19 | .10 | .23 | .11 | .10 | .02 | .25 | .31 | -.42 | -.41 | .19 | .27 | .28 | .27 | .29 | .23 | .10 | .22 | -.14 | .08 | .20 | .21 | .12 | .15 | -.28 | -.21 | -.27 | -.34 | -.18 | .70 | .70 |