

Factorial analyses in IT governance reveal constellations of decision shares and their consequences on IT in higher education institutions

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1. Abstract

The introduction of IT governance and the placement of CIOs at German institutions of higher education have been recommended for many years. In order to control digitization in higher education, a strategic concept to align business and IT as defined in IT governance is essential. However, who is involved in the decision-making processes very often depends on local conditions and the organizational culture and tradition. This aggravates the evaluation of the implemented models and the statistical comparison of their effectiveness. For the CIO study 2017 in Germany, representatives of 28 higher education institutions participated. They categorised their governance model and gave estimates of IT-relevant topics.

Our central research question focused on correlations between how decisions are made and how important these topics are regarded by decision makers. The results show that depending on who is involved in the process for decisions from the five classical domains, the estimates vary. To demonstrate this point, two principal component analyses (PCAs) and two factor analyses (FAs) were conducted. Finally, a model with typical constellations as alliances between the decision makers was derived.

2. Introduction

Institutions of higher education are often described as systems with loosely tied decision makers [We76], resulting in ambiguity often described as a “garbage can model” [COM72, MO86]. This results in a system made up of autonomic subsystems, a system of systems (SoS) [SBG09]. To control these, clear and trusted processes of decision-making are needed: a governance. In 2002, the CIO was prompted to introduce an IT governance structure at TU München by the general difficulty of balancing between regulation and autonomy [Bo02]. Unfortunately, many institutions still need to establish effective IT governance [Wi17] as advised by the DFG [Dfg16]. Governance is questioned in the context of digitization regarding its control on influences from outside the institution [HAHE17]. In particular, the decentralised nature of decision-making in German universities [Wi16] collides with the central control suggested by most IT governance models. If we follow Weill and Ross’s [WR04] archetypes of IT governance, German universities tend to represent either a business monarchy (in the decentralised faculties) or a duopoly.

The first to study CIO models in higher education institutions (HEI) in Germany was Schwabe [Sc09]. He compared distribution of authority to decide and maturity of models, using data from universities in Germany, Switzerland and Austria. However, he did not examine other factors but focused on the differences between the countries. Further studies pointed out the different roles for CIOs in HEI in Germany [HB15] or compared different governance models [HWHL16, He15].

But which aspects will actually change if governance is introduced? Will the newly created structure be capable of making decisions and leading the institution? The CIO study 2016 in Germany tried to evaluate effectiveness [HB16, HB17b], and the relationship to the Global Complexity Index (GCI)

[HB17a] regarding exclusively significant correlations. What causes the correlations has not been examined.

The current study follows these questions:

1. Are any factors correlated with who gets to decide to what extent? Is there a systematic difference in the institution, if different roles take part in the decision-making?
2. Does the analysis allow us to specify models for IT governance which are working regardless of strong personalities?

The study will not examine the causes for the correlations found. The use of factor analysis makes the data more easily interpretable by the reader.

3. Methodology

Web-based questionnaires were sent to about 400 representatives of all HEI in Germany, asking about basic statistics, the implemented governance model, and estimates of the functioning of IT using sliders. In total 32 institutions participated; after a plausibility probe, 28 nearly complete sets of data could be used for further analysis. Excluded were sets when less than 25% of the questions were answered, when the answers contained several obvious contradictions, or when the questionnaire was filled in systematically with always the same answer.

Following Weill and Ross we distinguish five domains of decision-making: IT strategy, IT architecture, IT infrastructure, IT applications, and priority and budget [WR4]. The suggested archetypes for decision makers can be matched with the persons involved in the decision-making process in HEI: the executive committee, vice president, head of administration, CIO, head of the IT service centre, heads of other administrative departments, IT board, and deans of departments [LW14].

The number of decision makers per domain defines their share in this domain. Added up, the shares over all domains identify the importance of each decision maker. If we define:

- M = one decision maker
- D_i = one decision domain with i between [1..5]
- N_D = number of decision makers of the domain D_i
- $P_{M,D}$ = participation of the respective decision maker M in the domain D_i [0 = false, 1 = true]
- S_M = share in decision-making process of the decision maker M

the share of one decision maker is calculated as: $S_M = \text{Sum of all } D_i (P_{M,D} / N_D)$.

These shares were combined with two selections of different variables. The first set contained questions around aspects of size, cost, stability, de-/centralisation, projects, and goals. The second set contained variables connected to service management, cost distribution, ratio of third party funding, and the focus of the institution on research or teaching and learning. Eligible variables have

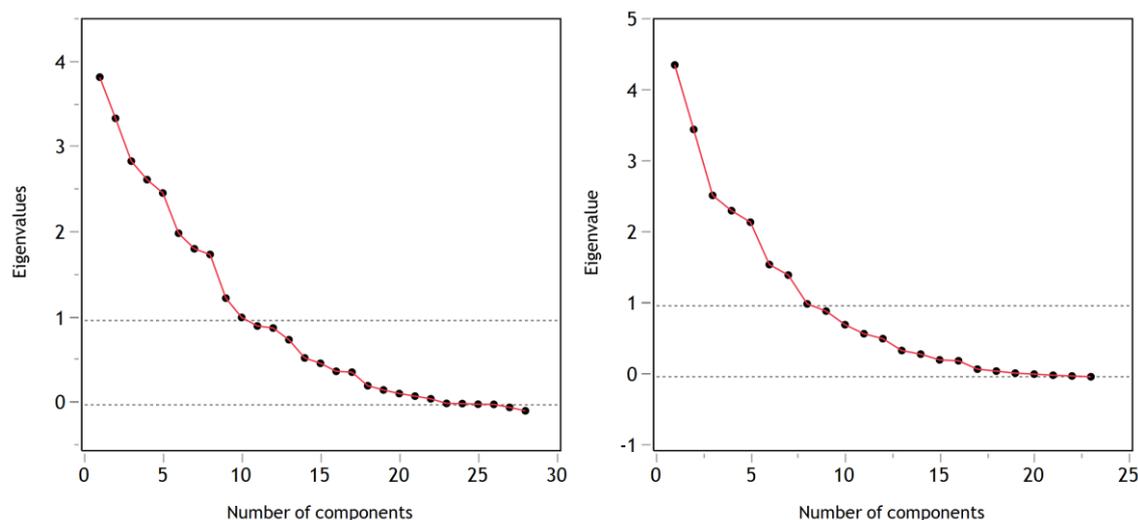


Figure 1: Scree plots for PCA I (left) and PCA II (right)

to be distributed sufficiently following Gaussian distribution, thus qualifying for a factor analysis (FA). The selection of variables was checked for stability by systematically removing variables and data and still receiving valid results. For these sets we ran a principal component analysis (PCA) on pairwise correlations and extracted the eigenvalues.

Obligations for equal distribution of examined variants were verified with Bartlett's test. Chi² values of the specific combination of variables stayed above the variance of the eigenvalues with a significance level of 5%. Therefore, it can be concluded that all requirements to execute a factor analysis are fulfilled. The number of factors which should be considered in the FAs was identified by the parallel analysis method in the Scree plots (see Figure 1). For both FAs, five factors were identified as suitable.

All factor loadings were Varimax rotated and are discussed if the absolute value is > 0.4. All loadings with an absolute value > 0.3 are displayed in the results section; all numbers are listed in the appendix.

4. Results

The results for both sub-sets of our data are discussed in sequence.

4.1. Data set 1: Size, cost, stability, de- / centralisation, projects, goals

PCA I

The Scree plot of the first PCA suggested conducting the factor analysis with five factors. The cumulative explained variance of the sample was about 65% for the first five Eigenvalues.

FA I - Factor 1 - Global Complexity Index

| Short Name | Factor Loading | Actual question from the web questionnaire translated into English (all following tables have the same heading) |
|-------------------|----------------|---|
| budget | 0,98 | The budget 2016 for the institution excluding third-party funds was: |
| third-party funds | 0,95 | The third-party funds in 2016 amounted to: |
| employees | 0,94 | How many employees work at your institution? [reference date 31.12.16 in FTE] |
| students | 0,87 | How many students are registered at your institution? [number from official statistics at the start of winter term 2016/17] |

The four factor loadings are directly linked with the size of the institution. The component "budget" is not part of the Global Complexity Index (GCI) but is very closely related. Factor 1 therefore confirms the GCI being the most important explanation for differences between institutions. Further comparative analyses were planned in 2016 and are currently conducted by Bergström et al. [BKL16]. Examination of the other factors might provide valuable additions to the project.

FA I - Factor 2 - Distributed IT with increasing costs

| | | |
|------------------|-------|--|
| many departments | 0,73 | Many different departments contribute to IT services at my institution. |
| decision CIO | -0,67 | Share in decision-making process (CIO) |
| decision head | 0,63 | Share in decision-making process (head of administration) |
| Wages | -0,61 | IT personnel at my institution receive adequate wages for their work. |
| future costs | 0,57 | IT costs at my institution are expected to rise within the next three years. |
| decision IT | 0,53 | Share in decision-making process (head of IT service centre) |

| | | |
|----------------------|-------|---|
| decision departments | 0,46 | Share in decision-making process (departments) |
| stable | -0,37 | My institution expects IT to run in a stable way. |
| decision board | -0,36 | Share in decision-making process (IT board) |

In institutions with many departments contributing to IT services (many departments), the shares in the decision-making process of the head of administration (decision head) and of the head of IT service centre (decision IT) are higher; the shares of the CIO are lower (decision CIO). At the same time wages of IT personnel are estimated inadequate (wages). The costs for IT are expected to rise within the next three years (future costs).

FA I - Factor 3 - Centralised and stable IT

| | | |
|-----------------|-------|--|
| centralised | 0,71 | IT services at my institution are organised centrally. |
| decision VP | 0,70 | Share in decision-making process (vice president) |
| decision IT | -0,64 | Share in decision-making process (head of IT service centre) |
| stable | 0,57 | My institution expects IT to run in a stable way. |
| decision others | 0,50 | Share in decision-making process (other heads) |
| future costs | 0,47 | IT costs at my institution are expected to rise within the next three years. |
| documentation | -0,45 | Processes for IT are not well documented at my institution. |
| goals | -0,37 | The management of my institution negotiates precise goals with me. |

Apparently the variable (many departments) is not correlated with central organisation of IT services (centralised), meaning one is not the opposite of the other.

In factor 3 the central IT service organisation (centralised) is connected with the demand for stable IT service (stable). The necessary decisions are made more by the vice president and less by the head of IT services. At the same time documentation is seen as rather sufficient (documentation); differently phrased, centralised IT is seen in connection with stability. As with factor 2 costs are expected to rise.

FA I - Factor 4 - Processes and information security

| | | |
|----------------------|-------|--|
| processes | 0,79 | IT in my institution follows defined processes. |
| information security | 0,72 | Information security has a clear meaning for most users at my institution. |
| documentation | -0,66 | Processes for IT are not well documented at my institution. |
| goals | 0,55 | The management of my institution negotiates precise goals with me. |
| decision head | 0,51 | Share in decision-making process (head of administration) |

Factor 4 focuses on process orientation of the institution. Clearly defined processes (processes) and an understanding of security (information security) are correlated with satisfying documentation. Management leads employees to define goals (goals). In this scenario the head of administration is very often influential (decision head).

FA I - Factor 5 - Creative solutions without projects

| | | |
|----------|-------|--|
| projects | -0,70 | Organisational changes are always implemented through projects at my |
|----------|-------|--|

| | | |
|---------------------|-------|---|
| | | institution. |
| creative solutions | 0,68 | The management of my institution expects creative IT solutions. |
| decision executives | 0,55 | Share in decision-making process (executive committee) |
| decision board | 0,55 | Share in decision-making process (IT board) |
| decision CIO | -0,49 | Share in decision-making process (CIO) |
| decision others | -0,40 | Share in decision-making process (other heads) |
| decision VP | 0,37 | Share in decision-making process (vice president) |

Factor 5 sees an accumulation of shares in decision-making. The negative factor loading for organisational changes implemented through projects (projects) stands in contrast with the expectation of creative solutions (creative solutions). The expectation apparently is mainly carried by the executive committee and the IT board, and to a smaller degree by the vice president. The shares of the CIO and other department heads have a negative loading and can be interpreted as counterparts to this scenario. In other words, the CIO and department heads seem to prefer project-oriented processes while they are not expected to resort to creative solutions.

4.2. Data set 2: Service management, cost distribution, focus

In the second PCA, several attributes concerning service management were related to the shares of decision-making. In addition, variables describing the difference between research-oriented institutions and teaching and learning institutions as well as the rate of third party funding were included.

PCA II

We used the Scree plot to determine the number of factors for the subsequent FA with five factors. The cumulative explained variance of the sample was about 54% for the first five eigenvalues. The factorial analysis was performed on the correlations.

FA II - Factor 1 - Cost orientation

| Short Name | Factor Loading | Actual question from the web questionnaire translated into English |
|---------------------|----------------|--|
| cost communication | 0,78 | Costs for every individual IT service are calculated and communicated. |
| decision VP | -0,69 | Share in decision-making process (vice president) |
| cost splitting | 0,55 | Costs for IT services are split among clients relating to causes and volumes. |
| service design | 0,53 | IT services are based on current and future values of core processes. |
| SLAs | 0,52 | Our IT services have been negotiated and laid down in SLAs with our clients or their representatives. |
| traditional | -0,49 | IT services are founded in the traditions of a scientific data centre. |
| offer | -0,43 | The IT service centre offers IT services according to their point of view. |
| governance workload | -0,40 | How much time overall do you, your employees, a board, a committee etc. spend with the CIO's tasks [in FTE]? |
| past costs | -0,38 | IT costs at my institution have risen in the past three years. |

| | | |
|-----------------|-------|--|
| future costs | -0,37 | IT costs at my institution are expected to rise within the next three years. |
| ratio | 0,37 | Ratio of third-party funds to total funds |
| decision CIO | 0,34 | Share in decision-making process (CIO) |
| decision others | -0,34 | Share in decision-making process (other heads) |

Factor 1's highest component is the confirmation of communicated IT costs (cost communication). Other high loadings are splitting of IT costs in relation to cause and volume (cost splitting), service design based on the value of core processes (service design), and services agreed upon in SLAs (SLAs). In contrast, the shares of the vice president show a negative loading (decision VP), as well as services based on traditions (traditional) and services according to the service centre's point of view (offer).

An interesting fact is that the variable judging the time spent on governance tasks is loaded negatively (governance workload), suggesting that cost-oriented service management is not regarded as a governance task. On the other hand, traditional scientific data centres are in accordance with the time spent for governance tasks.

According to the analysis, institutions with a high ratio of third-party funding (ratio) also have a cost-oriented approach to service management. However, factor loadings below 0.4 shall not be taken into account in this publication; they might be the subject of further investigation.

FA II - Factor 2 - Service and value orientation

| | | |
|----------------------|-------|---|
| service orientation | 0,80 | All departments and administration are provided with IT services. |
| informal | -0,74 | IT services are not well defined and supplied without obligation (e.g. best effort). |
| unknown value | -0,63 | The value of IT services is unknown. |
| CIO's workload | 0,57 | How much time does the CIO spend with IT governance / IT strategy tasks [percentage of FTE]? |
| SLAs | 0,50 | Our IT services have been negotiated and laid down in SLAs with our clients or their representatives. |
| decision head | 0,45 | Share in decision-making process (head of administration) |
| decision CIO | -0,40 | Share in decision-making process (CIO) |
| documentation | -0,34 | Processes for IT are not well documented at my institution. |
| decision departments | 0,30 | Share in decision-making process (departments) |

Factor 2's main component is provision of IT service for all departments and administration (service orientation). The negative loading of undefined services without obligation enhances this. At the same time, service level agreements are expected (SLAs). The value of IT is well known (unknown value) and the CIO's workload is correlated with that (CIO's workload). But the CIO's shares in decision-making are negatively loaded and therefore reduced in this scenario (decision CIO). The head of administration has a positive factor loading for his share (decision head).

FA II - Factor 3 - Decentralised services and research orientation

| | | |
|-------------|-------|--|
| decision IT | 0,82 | Share in decision-making process (head of IT service centre) |
| obtain | -0,72 | IT services have to be obtained from the central IT centre. |

| | | |
|----------------------|-------|---|
| decision CIO | -0,55 | Share in decision-making process (CIO) |
| focus | -0,53 | The focus of my institution is on research...both...teaching and learning |
| documentation | 0,52 | Processes for IT are not well documented at my institution. |
| ratio | 0,50 | Ratio of third-party funds to total funds |
| decision departments | 0,47 | Share in decision-making process (departments) |
| decision board | -0,39 | Share in decision-making process (IT board) |
| SLAs | -0,37 | Our IT services have been negotiated and laid down in SLAs with our clients or their representatives. |
| decision head | 0,37 | Share in decision-making process (head of administration) |

Factor 3 includes high shares of decision-making on the head of the IT service centre's side (decision IT). But not all services have to be obtained from the central service centre (obtain). Apparently the services are just an offer from the centre, leaving it to the departments to accept. Matching this thought, the heads of department are well involved in the decision-making process (decision departments) whereas the CIO's share of decision-making (decision CIO) has negative loading. Documentation for IT processes could be improved (documentation).

Value for the focus of the institution is spread from research towards teaching and learning, meaning the negative loading as a lower number tends towards research (focus). Generally institutions concentrating on research are rare in the study; the average value claims teaching and learning as focus. In correlation with the third-party ratio (ratio), however, this makes sense: Institutions with influential decision makers in the departments can be more research oriented and might have more third-party funding for their research.

FA II - Factor 4 - Decide at the executive committee to secure funding

| | | |
|----------------------|-------|--|
| governance workload | -0,71 | How much time overall do you, your employees, a board, a committee etc. spend with the CIO's tasks [in FTE]? |
| secured funding | 0,68 | Financing for IT at my institution has been secured for future years. |
| decision executives | 0,66 | Share in decision-making process (executive committee) |
| decision CIO | -0,46 | Share in decision-making process (CIO) |
| decision head | -0,45 | Share in decision-making process (head of administration) |
| decision board | 0,43 | Share in decision-making process (IT board) |
| decision departments | 0,34 | Share in decision-making process (departments) |
| decision VP | 0,32 | Share in decision-making process (vice president) |
| central budget | 0,31 | IT services are financed through central budget. |
| cost splitting | 0,30 | Costs for IT services are split among clients relating to causes and volumes. |

Factor 4 is connected with the distribution of the decision shares between different parties, much like factor 5 in the first FA. The governance workload with negative loading is the highest component in factor 4 (governance workload). In contrast, funding for IT for future years has been secured (secured funding). This suggests that institutions that spend more time on governance tasks are less sure about how to finance IT in the future, which is an unexpected connection.

While shares of the executive committee (decision executives) and the IT board (decision board) have a positive loading, shares of head of administration (decision head) and CIO (decision CIO) are loaded negatively. The correlation of these shares with a lack of governance workload is noteworthy.

FA II - Factor 5 - Decentral, non-binding offers with higher future costs

| | | |
|----------------------|-------|---|
| non-binding | 0,81 | The offers of the IT service centre are non-binding. |
| central budget | -0,56 | IT services are financed through central budget. |
| future costs | 0,52 | IT costs at my institution are expected to rise within the next three years. |
| offer | 0,46 | The IT service centre offers IT services according to their point of view. |
| past costs | 0,40 | IT costs at my institution have risen in the past three years. |
| focus | -0,39 | The focus of my institution is on research...both...teaching and learning |
| decision departments | 0,36 | Share in decision-making process (departments) |
| decision head | 0,36 | Share in decision-making process (head of administration) |
| documentation | -0,35 | Processes for IT are not well documented at my institution. |
| SLAs | 0,32 | Our IT services have been negotiated and laid down in SLAs with our clients or their representatives. |
| CIOs workload | -0,32 | How much time does the CIO spend with IT governance / IT strategy tasks [percentage of FTE]? |

Factor 5’s highest component is the fact that the offers from the IT service centre are non-binding (non-binding). The services offered follow the service centre’s point of view (offer), costs have risen (past costs) and are expected to rise further (future costs), while they are not financed through a central budget (central budget) but e.g. per apportionment or means from projects. The focus of the institutions tends towards research (focus).

In the reverse conclusion, institutions focusing on teaching and learning expect costs not to rise but be financed in the central budget.

Noteworthy is the lack of high shares in decision-making in this factor; this might suggest that decision makers are not clearly identified and decisions are made locally and without coordination.

5. Interpretation

Even though some factors have very dominant variables, they cannot be reduced to that one variable. The correlations of the other variables have to be acknowledged. Therefore, changing only one is no solution. Factor analysis, however, allows us at least understanding to some degree. It provides the variables which are correlated and also shows some that do not have any influence at all.

The scenarios presented through the factors are often feasible and match the way many CIOs and heads of IT service centres view HEI in Germany. Only the correlation of negatively loaded governance workload with secured funding comes as a surprise; however, it could be plausible that “since the funding is secured, the governance workload has shrunk”.

The factors in which several shares of decision-making appear in parallel allow us to understand the governance models already implemented in the addressed institutions (see Figure 2). The respective factors label the connections between co-varying decision shares. Alliances (vertical red connections) can be observed for co-varying factors with the same factor loading. Opposing decision shares are observed along the horizontal blue connections (contra-varying factors).

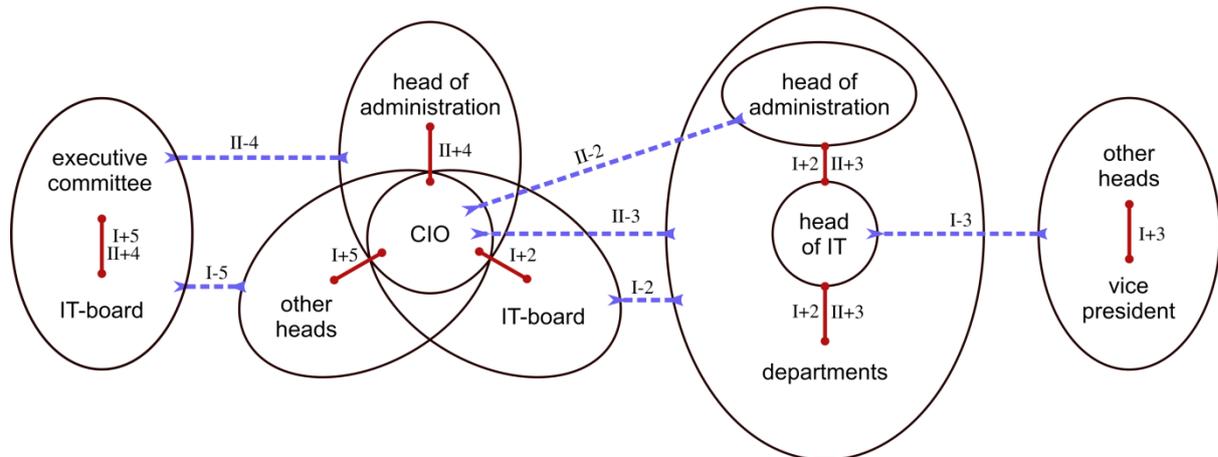


Figure 2: Opposing/- (horizontal/blue) or supporting/+ (vertical/red) decision shares as derived from FAs I and II. The Arabic number refers to the respective factor with the FA.

6. Summary

The CIO study 2017 in Germany collected data sets from 28 institutions for higher education and was able to draw conclusions by performing principal component analyses (PCA) and factor analyses (FA) systematically. Five factors each combined essential variables and reveal the following:

- FA I-1: The components of the GCI are confirmed.
- FA I-2: Institutions with high shares of decision-making for the head of administration and the head of the IT service centre maintain several IT departments and expect more rising costs than others.
- FA I-3: Centralised IT services trigger expectations for stability, but the head of IT services loses influence on decision-making.
- FA I-4: Process orientation and information security is driven by a higher decision-making share for the head of administration.
- FA I-5: Executives' decisions go along with high expectations for creative solutions, but neglect project management for organisational changes.
- FA II-1: The VPs' decision shares do not focus on the communication of IT service costs or cost awareness.
- FA II-2: The CIOs' workload benefits service orientation and value of IT, which contradicts the classical offer-oriented data center-driven services.
- FA II-3: Having a powerful head of IT services goes well with a focus on research, but displays a lack of documentation for the decentralised IT services.
- FA II-4: Decisions by the executive committee are a way to secure funding for IT, which in turn does not result in a high workload for IT governance.
- FA II-5: Decentralised IT services are more expensive in the past and future, even without centralised IT budgets.

Overall, these results confirm the use of modern management methods by well-known IT frameworks like Cobit, ISO38500, ITIL and others. This means that institutions of higher education, even though their internal proceedings seem often rather complex, can in fact be led with the support of these concepts. IT governance, in the meaning of managing a system of systems (SoS), can dissolve the discrepancy between central regulation and decentralised autonomy, if this governance really leads and is not mixed up with mere micro-management. Decision-making power with validation for the entire institution has to be tied purposefully to roles; in an ideal case, this will result in improvement in service management and financial stability for IT.

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8. Appendix

PCA I: Principal components based on correlations:

| Number | Eigen-value | Percent | Cum. Percent | Chi ² | Degree of freedom | Probability > Chi ² | Significance |
|--------|-------------|---------|--------------|------------------|-------------------|--------------------------------|--------------|
| 1 | 4,3808 | 19,047 | 19,047 | 485,474 | 252,915 | <,0001 | ++ |
| 2 | 3,4728 | 15,099 | 34,146 | 428,897 | 238,229 | <,0001 | + |
| 3 | 2,5440 | 11,061 | 45,207 | 379,490 | 222,332 | <,0001 | + |
| 4 | 2,3288 | 10,125 | 55,332 | 341,006 | 205,276 | <,0001 | + |
| 5 | 2,1663 | 9,418 | 64,751 | 301,936 | 188,428 | <,0001 | + |
| 6 | 1,5698 | 6,825 | 71,576 | 260,443 | 172,121 | <,0001 | |
| 7 | 1,4220 | 6,183 | 77,759 | 228,198 | 155,609 | 0,0001 | |
| 8 | 1,0158 | 4,416 | 82,175 | 195,004 | 139,702 | 0,0014 | |
| 9 | 0,9147 | 3,977 | 86,152 | 169,928 | 124,087 | 0,0040 | |
| 10 | 0,7227 | 3,142 | 89,294 | 144,415 | 109,272 | 0,0137 | |
| 11 | 0,5956 | 2,589 | 91,883 | 122,312 | 95,179 | 0,0319 | |
| 12 | 0,5259 | 2,286 | 94,170 | 101,969 | 81,982 | 0,0667 | |
| 13 | 0,3585 | 1,559 | 95,728 | 80,700 | 69,691 | 0,1728 | |
| 14 | 0,3080 | 1,339 | 97,068 | 65,170 | 58,254 | 0,2488 | |
| 15 | 0,2267 | 0,985 | 98,053 | 49,184 | 47,763 | 0,4160 | |
| 16 | 0,2147 | 0,933 | 98,986 | 35,568 | 38,099 | 0,5869 | |
| 17 | 0,0967 | 0,420 | 99,407 | 15,806 | 29,554 | 0,9816 | |
| 18 | 0,069 | 0,300 | 99,707 | 6,673 | 22,025 | 0,9993 | |
| 19 | 0,0402 | 0,175 | 99,882 | . | 15,533 | . | |
| 20 | 0,0266 | 0,116 | 99,998 | . | 10,256 | . | |
| 21 | 0,011 | 0,048 | 100,045 | . | 5,758 | . | |
| 22 | 0,0001 | 0 | 100,046 | . | 2,475 | . | |

Varimax rotated factor loadings of FA I in descending order of sum of absolute factor loading:

| Explained Variance | Short Name | Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|--------------------|----------------------|---|----------|----------|----------|----------|----------|
| 0,779 | "decision VP" | Share in decision-making process (vice president) | 0,229 | 0,132 | 0,702 | -0,287 | 0,366 |
| 0,699 | "future costs" | IT costs at my institution are expected to rise within the next three years. | -0,281 | 0,569 | 0,469 | 0,278 | -0,005 |
| 0,593 | "goals" | The management of my institution negotiates precise goals with me. | -0,162 | 0,276 | -0,367 | 0,548 | 0,237 |
| 0,723 | "decision head" | Share in decision-making process (head of administration) | -0,056 | 0,629 | -0,139 | 0,513 | -0,205 |
| 0,702 | "documentation" | Processes for IT are not well documented at my institution. | 0,106 | 0,220 | -0,450 | -0,662 | -0,039 |
| 0,769 | "processes" | IT in my institution follows defined processes. | -0,051 | -0,276 | 0,227 | 0,791 | -0,113 |
| 0,871 | "students" | How many students are registered at your institution? [number from official statistics at the start of winter term 2016/17] | 0,871 | -0,276 | 0,164 | 0,000 | 0,099 |
| 0,635 | "creative solutions" | The management of my institution expects creative IT solutions. | -0,135 | 0,033 | -0,268 | 0,289 | 0,679 |

| | | | | | | | |
|-------|------------------------|--|--------|--------|--------|--------|--------|
| 0,536 | "stable" | My institution expects IT to run in a stable way. | -0,070 | -0,368 | 0,566 | 0,219 | -0,163 |
| 0,716 | "decision IT" | Share in decision-making process (head of IT service centre) | -0,133 | 0,530 | -0,644 | 0,019 | -0,048 |
| 0,474 | "decision others" | Share in decision-making process (other heads) | 0,130 | 0,216 | 0,497 | 0,072 | -0,397 |
| 0,700 | "decision CIO" | Share in decision-making process (CIO) | -0,016 | -0,669 | 0,080 | -0,038 | -0,495 |
| 0,479 | "decision board" | Share in decision-making process (IT board) | 0,186 | -0,356 | -0,073 | 0,121 | 0,546 |
| 0,483 | "wages" | IT personnel at my institution receive adequate wages for their work. | -0,114 | -0,611 | -0,102 | 0,230 | 0,183 |
| 0,916 | "third-party funds" | The third-party funds in 2016 amounted to: | 0,948 | 0,061 | -0,088 | -0,032 | -0,077 |
| 0,914 | "employees" | How many employees work at your institution? [reference date 31. Dec. 2016 in FTE] | 0,942 | 0,056 | 0,011 | -0,049 | -0,146 |
| 0,981 | "budget" | The budget 2016 for the institution excluding third-party funds was: | 0,982 | -0,037 | 0,103 | -0,074 | 0,004 |
| 0,619 | "many departments" | Many different departments contribute to IT services at my institution. | 0,019 | 0,725 | -0,291 | -0,073 | -0,051 |
| 0,568 | "projects" | Organisational changes are always implemented through projects at my institution. | -0,050 | -0,053 | -0,229 | 0,116 | -0,705 |
| 0,401 | "decision executives" | Share in decision-making process (executive committee) | -0,196 | -0,006 | 0,168 | -0,176 | 0,551 |
| 0,581 | "information security" | Information security has a clear meaning for most users at my institution. | 0,057 | -0,026 | -0,235 | 0,722 | -0,014 |
| 0,526 | "centralised" | IT services at my institution are organised centrally. | -0,005 | -0,084 | 0,706 | -0,088 | 0,113 |
| 0,229 | "decision departments" | Share in decision-making process (departments) | -0,079 | 0,462 | -0,029 | -0,088 | 0,019 |

PCA II: Principal components based on correlations:

| Number | Eigen-value | Percent | Cum. Percent | Chi ² | Degree of freedom | Probability > Chi ² | Significance |
|--------|-------------|---------|--------------|------------------|-------------------|--------------------------------|--------------|
| 1 | 3,8411 | 13,718 | 13,718 | 509,21 | 378,173 | <,0001 | + |
| 2 | 3,3582 | 11,994 | 25,712 | 462,476 | 357,408 | 0,0001 | + |
| 3 | 2,8557 | 10,199 | 35,911 | 419,023 | 336,336 | 0,0014 | + |
| 4 | 2,6379 | 9,421 | 45,332 | 379,89 | 314,995 | 0,0071 | + |
| 5 | 2,4814 | 8,862 | 54,194 | 341,347 | 293,979 | 0,0297 | + |
| 6 | 2,0086 | 7,174 | 61,367 | 302,255 | 273,433 | 0,1112 | |
| 7 | 1,8267 | 6,524 | 67,891 | 268,573 | 252,924 | 0,2384 | |
| 8 | 1,7600 | 6,286 | 74,177 | 235,614 | 232,903 | 0,4380 | |
| 9 | 1,2474 | 4,455 | 78,632 | 200,611 | 213,593 | 0,7287 | |
| 10 | 1,0207 | 3,645 | 82,277 | 174,458 | 194,433 | 0,8451 | |
| 11 | 0,9206 | 3,288 | 85,565 | 151,836 | 175,822 | 0,9043 | |
| 12 | 0,8965 | 3,202 | 88,767 | 130,015 | 158,060 | 0,9499 | |
| 13 | 0,7590 | 2,711 | 91,477 | 106,568 | 141,159 | 0,9866 | |
| 14 | 0,5453 | 1,948 | 93,425 | 84,665 | 125,048 | 0,9978 | |
| 15 | 0,4822 | 1,722 | 95,147 | 68,020 | 109,83 | 0,9994 | |

| | | | | | | | |
|----|--------|-------|---------|--------|--------|--------|--|
| 16 | 0,3886 | 1,388 | 96,535 | 51,821 | 95,452 | 0,9999 | |
| 17 | 0,3781 | 1,350 | 97,885 | 37,570 | 81,986 | 1 | |
| 18 | 0,2195 | 0,784 | 98,669 | 20,605 | 69,533 | 1 | |
| 19 | 0,1694 | 0,605 | 99,274 | 10,569 | 58,010 | 1 | |
| 20 | 0,1272 | 0,454 | 99,729 | 2,092 | 47,461 | 1 | |
| 21 | 0,0972 | 0,347 | 100,076 | . | 37,876 | . | |
| 22 | 0,0654 | 0,234 | 100,310 | . | 29,366 | . | |
| 23 | 0,0116 | 0,041 | 100,351 | . | 21,803 | . | |
| 24 | 0,0095 | 0,034 | 100,385 | . | 15,314 | . | |
| 25 | 0,0021 | 0,008 | 100,393 | . | 10,005 | . | |
| 26 | 0,0002 | 0,001 | 100,394 | . | 5,490 | . | |

Varimax rotated factor loadings of FA II in descending order of sum of absolute factor loading:

| Explained Variance | Short Name | Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|--------------------|------------------------|--|----------|----------|----------|----------|----------|
| 0,790 | "decision CIO" | Share in decision-making process (CIO) | 0,340 | -0,402 | -0,545 | -0,464 | -0,005 |
| 0,764 | "SLAs" | Our IT services have been negotiated and laid down in SLAs with our clients or their representatives. | 0,519 | 0,499 | -0,375 | 0,036 | 0,323 |
| 0,676 | "decision head" | Share in decision-making process (head of administration) | -0,043 | 0,448 | 0,366 | -0,454 | 0,365 |
| 0,584 | "decision departments" | Share in decision-making process (departments) | 0,145 | 0,304 | 0,472 | 0,337 | 0,365 |
| 0,762 | "governance workload" | How much time overall do you, your employees, a board, a committee etc. spend with the CIO's tasks [in FTE]? | -0,400 | 0,226 | 0,060 | -0,706 | -0,222 |
| 0,732 | "informal" | IT services are not well defined and supplied without obligation (e.g. best effort). | -0,295 | -0,741 | 0,065 | -0,262 | 0,154 |
| 0,501 | "ratio" | Ratio of third-party funds to total funds | 0,367 | -0,282 | 0,498 | 0,168 | 0,106 |
| 0,525 | "focus" | The focus of my institution is on research...both...teaching and learning | -0,091 | 0,252 | -0,526 | -0,157 | -0,390 |
| 0,531 | "documentation" | Processes for IT are not well documented at my institution. | 0,021 | -0,338 | 0,516 | -0,174 | -0,347 |
| 0,520 | "CIOs workload" | How much time does the CIO spend with IT governance / IT strategy tasks [percentage of FTE]? | -0,214 | 0,568 | 0,060 | -0,214 | -0,320 |
| 0,482 | "offer" | The IT service centre offers IT services according to their point of view. | -0,428 | -0,232 | -0,003 | 0,195 | 0,455 |
| 0,485 | "future costs" | IT costs at my institution are expected to rise within the next three years. | -0,371 | 0,244 | -0,053 | -0,100 | 0,525 |
| 0,600 | "decision VP" | Share in decision-making process (vice president) | -0,686 | 0,136 | -0,099 | 0,315 | 0,042 |
| 0,718 | "decision IT" | Share in decision-making process (head of IT service centre) | 0,154 | 0,074 | 0,816 | -0,107 | -0,105 |
| 0,482 | "central budget" | IT services are financed through central budget. | -0,074 | 0,234 | -0,071 | 0,313 | -0,564 |
| 0,459 | "cost splitting" | Costs for IT services are split among clients relating to causes and volumes. | 0,546 | 0,020 | -0,240 | 0,304 | 0,105 |
| 0,585 | "obtain" | IT services have to be obtained from the central IT centre. | 0,143 | 0,136 | -0,719 | 0,168 | -0,030 |
| 0,521 | "decision executives" | Share in decision-making process (executive committee) | -0,087 | 0,038 | -0,082 | 0,660 | -0,264 |

| | | | | | | | |
|-------|-----------------------|--|--------|--------|--------|--------|--------|
| 0,671 | "non-binding" | The offers of the IT service centre are non-binding. | 0,027 | -0,095 | 0,048 | -0,093 | 0,807 |
| 0,639 | "cost communication" | Costs for every individual IT service are calculated and communicated. | 0,782 | -0,034 | -0,101 | -0,131 | 0,010 |
| 0,475 | "unknown value" | The value of IT services is unknown. | -0,078 | -0,632 | 0,259 | 0,029 | 0,035 |
| 0,356 | "decision board" | Share in decision-making process (IT board) | -0,059 | 0,049 | -0,394 | 0,431 | -0,095 |
| 0,349 | "service design" | IT services are based on current and future values of core processes. | 0,530 | 0,153 | 0,034 | 0,175 | -0,113 |
| 0,489 | "secured funding" | Financing for IT at my institution has been secured for future years. | -0,069 | 0,134 | 0,092 | 0,676 | 0,024 |
| 0,657 | "service orientation" | All departments and administration are provided with IT services. | -0,009 | 0,799 | -0,021 | 0,133 | -0,003 |
| 0,316 | "traditional" | IT services are founded in the traditions of a scientific data centre. | -0,489 | -0,190 | -0,181 | 0,087 | -0,012 |
| 0,312 | "past costs" | IT costs at my institution have risen in the past three years. | -0,376 | -0,014 | -0,073 | 0,069 | 0,401 |
| 0,192 | "decision others" | Share in decision-making process (other heads) | -0,338 | 0,097 | -0,203 | -0,122 | 0,109 |

9. Authors' Biographies



Dr. Markus von der Heyde received his PhD in Computer Sciences from the University of Bielefeld for his work at the Max Planck Institute for Biological Cybernetics Tübingen in 2000. His approach is to adopt biological principles into distributed computer applications in order to enhance stability and robustness.

Since 2004 he has worked within ZKI on topics such as information security, service management, strategy and governance. From 2003 to 2011 he was ICT director of Bauhaus University in Weimar. Since 2011 he has been a management consultant specializing in IT topics in higher education. In cooperation with various partners he has conducted the German CIO studies since 2014. Since 2016 he has organized the HEI CIOs congress in Germany. He supports ZKI, GI, EUNIS and EDUCAUSE, and serves as a program committee member as well as a proposal reviewer for conferences and the scientific community. Recently he was appointed Adjunct Professor in the School of Interactive Arts and Technology (SIAT) at Simon Fraser University (SFU), Vancouver. See more details on https://www.researchgate.net/profile/Markus_Von_Der_Heyde3.



Prof. Dr. Andreas Breiter is Professor of Information Management and Education Technologies at the University of Bremen and Scientific Director of the Institute for Information Management Bremen GmbH (ifib). His main areas of expertise are IT Management, IT Service Management and IT Controlling, Information Management in Education, E-Learning platforms, and Mediatization. He is also a member of working group 3.7 (IT in Educational Management) of the International Federation of Information Processing (IFIP), and a member of the Association for Computing Machinery (ACM). See further details on https://www.researchgate.net/profile/Andreas_Breiter.