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Exploring Innovation Capabilities of Hospital CIOs: An Empirical Assessment

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Abstract. Hospital CIOs play a central role in the adoption of innovative health IT. Until now, it remained unclear which particular conditions constitute their capability to innovate in terms of intrapersonal as well as organisational factors. An inventory of 20 items was developed to capture these conditions and examined by analysing data obtained from 164 German hospital CIOs. Principal component analysis resulted in three internally consistent components that constitute large portions of the CIOs innovation capability: organisational innovation culture, entrepreneurship personality and openness towards users. Results were used to build composite indicators that allow further evaluations.

Keywords. Innovation capability, Innovation management, composite indicator, hospital CIOs

1. Introduction

A rich body of studies agrees that Chief Information Officers (CIOs) occupy a central position in visioning, guiding and implementing IT based innovations [1,2]. These innovations can generally be defined as changes of products and processes that result from the adoption of IT and are new to the given organisation [3]. In the hospital context, IT innovations mostly fall under the category of process innovations (e.g. the widespread implementation of a new clinical decision support system or telemedicine solutions) that lead to significant changes of the related workflows or process outcomes [4].

Even though empirical investigations could substantiate the critical role of CIOs to foster IT innovations in the industrial sector [e.g. 5], there is no scientific evidence about the innovation capability of CIOs in healthcare, particularly in hospitals. In fact, there are reasons to assume, that hospital CIOs innovation attempts might be challenged by specific social and organisational circumstances [6]. Although medical decision-making processes cannot be entirely automated, as they require complex medical knowledge as well as the clinician's individual experience [7], the respective workflows can still be significantly improved by providing accurate data and information. The goal hereby is to seamlessly integrate the information flow into the clinician's work practice and particularly support advanced clinical processes. This phenomenon is described by the information logistics construct [8] which matches one of the criteria for innovation proposed by Hübner [4]. At this point, the innovational capability of the CIO often makes the difference between IT success and failure as they not only have to be very considerate

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with the clinician's expectations, autonomy and the peculiarities of the medical workflows, but also act in an environment that is characterised by financial restrictions [2]. Health information technology (HIT) is known to be frequently perceived as a mere cost factor by the executive board and therefore often lacks adequate support [9]. Specific innovation capabilities of CIOs may therefore be constituted by their ability to mediate between highly skilled professions and to act as an enabler within a potentially restrictive organisational environment. This is also referred to as *intrapreneurship* [10].

Up to date, empirical studies about hospital CIOs mainly focus on questions related to their structural power (position, reporting level etc.) [11] and on how these factors correlate with given CIO roles or decision types [9]. Whereas these approaches are meaningful in themselves, they often neglect the underlying personality (e.g. the CIOs views and attitudes) and environmental patterns (e.g. the executive board's attitude towards IT). Our goal, therefore, was to 1) shed light in what constitutes innovation capabilities of hospital CIOs both in terms of intrapersonal as well as organisational factors and 2) determine how the innovation capability construct can be operationalised.

2. Methods

Original scales were developed based on Patterson and colleagues' [3] framework of people relevant resources for innovation in organisations that distinguishes environmental factors tied to the workplace (external dimension) and intrapersonal factors (internal dimension). We initially operationalised each domain by 40 items on different types of scales. Pre-testing the inventory (undertaken by 6 hospital CIOs and 8 health IT researchers) resulted in a final inventory of 20 Items, 10 for each domain measured by Likert scales. Data were collected between February and April 2016 via an online survey. We obtained 164 valid responses from a total of 1284 contacted German CIOs (response rate 12.77%).

In order to 1) explore underlying patterns of our data, 2) reduce the inventory to a set of variables that describe innovation capability, 3) test the discriminant and convergent validity and reliability (using Cronbach's alpha) as well as to 4) develop an empirically founded composite indicator, we performed principal component analysis (PCA) [12]. Following strong recommendations of the methodological literature [13], we applied the underlying variable (UV) approach using polychoric correlation coefficients since all included variables were measured on ordinal scales. Applicability of the correlation matrix was evaluated based on the Kaiser-Meyer-Olkin (KMO) criterion and Bartlett's test of sphericity. Components were extracted if their eigenvalue exceeded 1, if all components explained at least 50% of the total variance and based on consulting the scree plot. We allowed the extracted components to correlate by using oblique rotation since we did not assume them to be entirely distinct from each other. To obtain a set of meaningful and discriminant items, we gradually removed items that could not be fitted in the component structure (i.e. showed heavy cross loadings or component loadings $< .5$ across different model solutions). The final solution was tested for reliability and then interpreted in a group discussion of eight experts (comprising health IT scientists, statisticians, management researchers and a psychologist).

Component loadings and eigenvalues were used to deploy a weighting scheme adapted from the Organisation for Economic Co-operation and Development (OECD) [14] in order to build a composite indicator for each component and for the full inventory that accentuates the components and corrects for statistically overlapping information.

3. Results

According to a KMO measure of .73 and a significant result of Bartlett's test of sphericity our data proved to be suited for PCA. Moreover, the sample to variable ratio was 13:1 and therefore was above recommended minimum ratios which typically range between 5:1 to 10:1 [15]. In the course of reducing the inventory, we attained a final set of 13 items that were ideally reflected in a solution comprising 3 components (Table 1) explaining 51% of the total variance. Interrelations between the components remained low with correlation coefficients less than .15.

Table 1. Component loading matrix. Loading below .3 are left blank

Item	Component		
	1	2	3
"Our executive board actively promotes innovative IT solutions."	.82		
"Our hospital has a well-defined future vision that is also being pursued by the IT department."	.74		
"Our hospital shows great flexibility when it comes to employing innovative IT."	.74		
"Our hospital is way too rigid on all levels of hierarchy to employ IT in a strategically meaningful fashion." (reverse coded)	.70		
"IT is perceived as a mere expense factor by our executive board way too often" (reverse coded)	.68		
"Our IT department is only able to provide highly valuable services if every employee consistently covers an unchanged range of tasks" (reverse coded)		.68	
"My work mainly consists of realising the wishes and ideas of other people." (reverse coded)		.66	
"As the person in charge of IT, I first of all rely on well-established IT solutions." (reverse coded)		.57	
"My work motivation would be significantly higher if I was paid adequately to my knowledge and skills." (reverse coded)		.52	
"A CIO has to first of all take care of technical and not people issues." (reverse coded)			.76
"It is very important to me to have great knowledge of the clinical processes in our hospital."			.63
"Listening and giving advice are the core competencies in my role as a CIO."			.62
"It is very important to us to incorporate the different clinical end users in our IT projects."			.56

The full scale showed acceptable reliability in terms of internal consistency with $\alpha = .71$. Similarly, component 1 showed good internal consistency ($\alpha = .78$) whereas components 2 ($\alpha = .64$) and 3 ($\alpha = .52$) showed lower but acceptable reliability values given the relatively low number of associated items. The components were interpreted as "organisational innovation culture" (component 1), "entrepreneurship personality" (component 2) and "openness towards users" (component 3).

Table 2. Descriptive statistics of the developed composite indicators (n = 164)

Composite Indicator	Mean	SD	Range	Skewness	Kurtosis
Full inventory	55.86	12.29	59.67	.15	-.34
Component 1	53.33	20.54	100	-.18	-.04
Component 2	42.25	15.23	86.66	.17	.41
Component 3	74.98	14.27	67.06	-.35	.06

Table 2 displays the distributional properties of the calculated composite indicators that were built using the data driven weighting scheme referred to above. Each indicator was scaled to range between 0 (complete disagreement with all related statements) and 100 (complete agreement with all related statements)

4. Discussion

The importance of the CIOs' innovation capability increases with the growing potentials and diffusion of HIT. Hitherto it remained unclear which particular conditions constitute these capabilities (research question 1) and how these conditions can be operationalised (research question 2).

Results of the PCA and subsequent score development indicated two essential findings with regard to question 1. At first, it confirmed a clear empirical distinction of the external dimension opposed to internal (intrapersonal) aspects, as all items of component 1 were originally intended to measure the environmental dimension. In contrast to interpreting this component as the general organisational environment it can be specified as organisational innovation culture and support from the executive board. This aligns well with existing theoretical knowledge pointing out the importance of top management support [16] that gives HIT based innovations the required flexibility [17], active financial promotion, and guiding principles and vision [2] for innovative HIT to prosper. All these aspects seem to be indicative of a coherent dimension describing a fundamentally positive attitude towards innovative IT within the organisation. The second finding reveals that the previously assumed "internal dimension" has to be broken down into two separate dimensions, i.e. into "entrepreneurship personality" and "openness towards users". "Entrepreneurship personality" is a composition of traits that embraces intrinsic motivation and self-determination, a mindset of internal freedom to deviate from established paths and to take risks. This is a clear contrast to tayloristic attitudes. "Openness towards users" is a trait that is closely related with "involvement of users" and "participation" of users, which is a well-known success factor in systems engineering [5] and in innovation alike [8]. Our initial thoughts on CIOs' specific requirement of closely incorporating the clinician's interests when striving for HIT innovations now show an empirical manifestation in this component.

With regard to question 2, the analysis led to a full set of 13 items measuring three different dimensions of innovation capability. Whereas internal consistency measures where satisfying for component 1, reliability measures for component 2 and 3 were marginally acceptable. Greater precision and redundancy in these domains are desirable in further investigations. However, the full set of items showed an acceptable internal consistency with $\alpha = .71$. It was reduced on the grounds of the PCA results. Although this is a common methodical approach [12], it potentially threatens the construct's integrity since a few aspects were removed which might have been retained if they were captured with greater redundancy (i.e. more questions). It therefore is reasonable to assume that there might be more to innovation capability beyond our model's dimensions. Another limitation arises from the modest response rate of 12.77% that might have caused a non-response bias in our sample. The results can therefore only be generalised with caution and require further validation in different samples.

The resulting composite indicator is normally distributed around a mean of 56 points (out of 100). Thus, innovation capability seems to be moderately advanced in German hospitals with clear potential for development. It is most notably that component 3 "openness towards users" showed significantly higher values with $\bar{x} = 75$ whereas component 2 "entrepreneurship personality" only showed an average score of 42. Many hospital CIOs apparently understand the importance of participation and user focus but are still surprisingly prone to a work approach that does not create much space for self-determination and deviation from established paths. The actual impact of the composite indicator and its subscales still needs to be tested against innovation performance

measures to further assess their validity and to determine which particular aspects most strongly drive HIT innovations. This study provides a fundamental toolset to do so.

5. Conclusion

This study gives insight into the constituents of the construct innovation capability of CIOs and defines a set of items to operationalise this construct. In contrast to previous findings, we not only distinguish between internal and environmental factors, but clearly denote them specifying the dimensions unique to hospital CIOs. We hereby lay the foundation of a psychometric inventory to measure innovation capability.

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