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DOI:
10.1504/IJNVO.2020.10028868

Document status and date:
Published: 01/01/2020

Document Version:
Publisher's PDF, also known as Version of record

Document license:
Taverne

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Article *in* International Journal of Networking and Virtual Organisations · January 2020

DOI: 10.1504/IJNVO.2020.108867

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Flexible collaboration infrastructures and healthcare information exchange in hospitals: an empirical resource-based perspective

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Abstract: Exchanging health information and data will enhance the efficiency, quality, cost-effectiveness, and even safety of healthcare practices. However, views and strategies differ on how hospitals can facilitate or enable this exchange process. This study explores a relationship between two constructs, i.e., a flexible collaboration infrastructure – an integrated set of IT assets and networking functionalities that support applications and enable business collaboration – and health information exchange. Second, we argue that the strength of this relationship is influenced by the degree to which hospitals deploy security measures. Findings – based on an SEM-PLS analysis on a sample of 983 European hospitals – show a positive relationship between the two constructs. We additionally find that hospitals' security measures to protect the confidentiality, integrity, and availability of the data condition this particular relationship. Our findings contribute to the literature and provide valuable insights for hospitals.

Keywords: flexible collaboration infrastructure; IT flexibility; IT capability; health information exchange; HIDE; PLS-MGA; data security; electronic medical record; resource-based view; hospitals.

Reference to this paper should be made as follows: van de Wetering, R. and Versendaal, J. (2020) 'Flexible collaboration infrastructures and healthcare information exchange in hospitals: an empirical resource-based perspective', *Int. J. Networking and Virtual Organisations*, Vol. 23, No. 2, pp.171–188.

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This paper is a revised and expanded version of a paper entitled 'How a flexible collaboration infrastructure impacts healthcare information exchange' presented at 31st Bled eConference Digital Transformation, Bled, Slovenia, 17–20 June 2018.

1 Introduction

Deployment of new digital strategies and innovative technologies is essential for organisations that want to survive in competitive and turbulent markets (Mithas et al., 2013; Lyytinen et al., 2016). This trend also holds for the healthcare sector where health budgets are reduced, where there is a need for more transparency, and enhanced individual and population health outcomes (Kohli and Tan, 2016; Hendrikx et al., 2013; Blumenthal, 2010). In healthcare, we explicitly see a development the management and decision-makers want to make sure that their resources and investments in and new information systems and information technology (IS/IT) are harnessed successfully (van de Wetering et al., 2018). Modern hospitals specifically use IS/IT to transform healthcare delivery processes, and thereby try to improve clinical quality, service efficiency, patient satisfaction and reduce costs (Curtright et al., 2000; Ahovuo et al., 2004; McGlynn et al., 2003; Chiasson et al., 2007; Lee et al., 2013). To this end, hospitals require having real-time healthcare information and (patient) data to capture a complete patient's picture and their behaviour (Vest et al., 2013; Hersh et al., 2015; Walker et al., 2005). Driven, also, by various mandatory requirements, we see a trend toward rapid digitisation of large amounts of patient data. This digitisation is often complemented by the capability of compiling and electronically exchanging interoperable data with other providers within the ecosystem (Walker et al., 2005).

Ever since the late 1980s scholars recognised that information sharing between organisations is essential in partnerships and collaborations between companies (Konsynski and McFarlan, 1990) and pivotal in achieving a business value in various markets and domains (Lotfi et al., 2013; Bagheri et al., 2016). The literature outlines that most of the benefits for the participants in information sharing relate to an enhancement of information provisioning to achieve business strategies, goals, enhanced efficiency of operations and more effective networking capabilities. Health information and data exchange (HIDE) enables hospitals to securely share (in real-time) clinical information, e.g., laboratory results, physician documentation, and medication lists across the organisations' boundaries (Vest et al., 2013). HIDE is, therefore, all about sharing and exchanging information in networked business ecosystems. There is substantial evidence that HIDE can enhance hospital operations, reduce cost, and improve patient outcomes (Hersh et al., 2015; Patel et al., 2011). Therefore, many hospitals are considering the adoption and use HIDE as a source of value (Patel et al., 2011; Walker et al., 2005). The recent attention to patient privacy (strengthened by the European General Data Regulation and Protection, GDPR, regulations) and systems security complement these observations.

Up until now, in practice, views differ on how hospitals can facilitate and enable HIDE in a safe and privacy-minded context, using specific IT configurations. Let alone, how the hospital, within the broader hospital ecosystem can leverage and deploy this strategic competence to enhance quality and services benefits. Typical collaboration systems and infrastructures do not adequately support organisations and business networks to exchange, use and leverage resources (Begole et al., 1999; Byrd and Turner, 2000). Flexible infrastructure configurations are considered a critical component to adapt and reconfigure IT architectures strategically and operationally, also in healthcare (Bhatt and Grover, 2005; Kung et al., 2016). HIDE, however, is still in the early adoption phase (Patel et al., 2011). Gartner classified HIDE as a real-time health system technology that is currently beyond the peak of inflated expectations and is now sliding through (Runyon and Pessin, 2017). Therefore, Gartner analysts observed inconsistent results from this technology and implementations often fail to deliver (Runyon and Pessin, 2017). Thus, the full potential of HIDE in practice currently remains mostly unrealised even as mature IS/IT can provide patients with instantaneous information from anywhere and anyone (Patel et al., 2011; Carvalho et al., 2017).

Hence, we motivate this work with the shortcomings and foundations of previous HIDE investigations. In this current study, we primarily focus on the question of whether, and if so, to what extent a hospital's flexible collaboration infrastructure (as of now: FCI) influences HIDE. This question is important because this aspect will lead to a broader understanding of IT implementations in hospitals. Also, the targeted use of IT is becoming even more critical in modern hospital enterprises, and it is not uncommon that IT can impede potential benefits (Brynjolfsson and Hitt, 2000; Overby et al., 2006; Weill et al., 2002). We derive the notion of FCI in this study from various relevant IT capabilities, i.e., IT flexibility and collaborative studies and perspectives (Weill and Vitale, 2002; Duncan; 1995, Broadbent et al., 1999; Camarinha-Matos et al., 2009; Österle et al., 2012). To this end, we consider hospitals' FCI as an integrated set of reliable IT assets and networking functionalities that support existing applications and anticipate and enable new possibilities with a nexus of relationships that can be forged within the hospital ecosystem. In practice, naturally, the exchange of health data should be accompanied by fitting security measures and procedures that contribute to confidentiality, integrity, availability, and timeliness of health information and patient's data (Sahama et al., 2013; Benharref and Serhani, 2014; Fedorowicz and Ray, 2004).

This paper follows the premise of the resource-based view of the firms (RBV) (Barney, 1991) as the theory base and focuses on the IT-driven aspects that enable HIDE in the hospital practice. This theory provides a solid foundation to think about how IT contributes to organisational benefits and IT/business value creation (Wade and Hulland, 2004).

The central premise of the RBV within the context of IT is that strategic IT investments in the organisation's IT platforms and IT resource portfolio are essential to develop and align firm-wide capabilities to gain benefits and performance enhancements (El Sawy and Pavlou, 2008; Mithas et al., 2012; Sheikh et al., 2015).

Given the above, the current paper raises the following two research questions:

1 'What is the impact of a hospital's FCI on HIDE?'

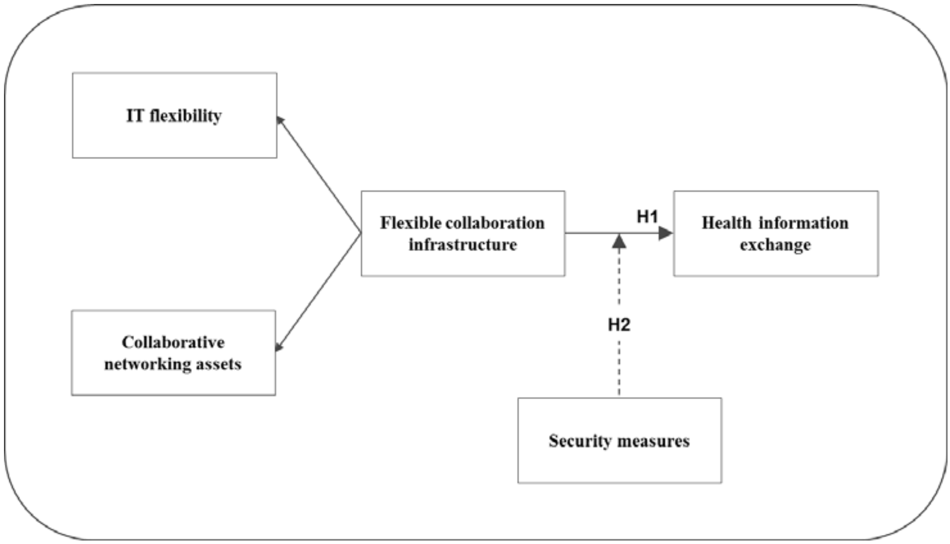
2 'What is the conditioning effect of deployed hospital's security measures on this particular relationship?'

This paper applies a positivistic approach whereby we focus on theoretical grounding and transparent research design, evidence, and a logical argument to find support for our central claim. This article is structured as follows. First, we first review the literature on the RBV and collaboration infrastructures. The RBV forms the theoretical foundation of this work and strengthens our contribution to the IS community. The methods and results section then follows these sections. We end with the main findings, discussions, inherent limitations of this study and we outline future research opportunities.

2 Theory and model development

In this research, we highlight the role of the RBV in the development of our research model and associated hypotheses. Hence, we use a digital strategy and capability building perspective to examine the impact of IT infrastructure capability on hospitals' level of HIDE. We also highlight the conditioning role of hospitals' deployed security measures in influencing the process of HIDE. Figure 1 shows our research model and captures the associated relationships. The model represents both a flexible collaboration infrastructure as reflective second-order latent constructs and HIDE as a first-order latent construct, in structural equation modelling (SEM) terms. First, will review the core notions of the RBV and its meaning within contemporary IS literature. We then subsequently review relevant literature and iteratively develop our hypotheses that we test using empirical data.

Figure 1 The proposed research model and associated hypotheses



2.1 The resource-based view of the firm

The RBV is an acknowledged theory within the management domain as well as within the IS community. The RBV explains how organisations achieve a competitive advantage as a result of the resources they own or have under their control (Barney, 1991). The RBV is grounded in foundational economic scholarship concerned with firm heterogeneity and imperfect competition (Chamberlin, 1937). The notion of resource in contemporary research was subsequently further split to encompass the processes of resource-picking and capability-building, two distinct facets central to the RBV (Makadok, 2001). Amit and Schoemaker (1993) define the firm's resources as tradable and non-specific firm assets, and capabilities as non-tradable firm-specific abilities to integrate, deploy, and use other resources within the firm. Thus, resources represent the input of the production process, while a firm's capability is the capacity to deploy these particular (IT) resources, aiming to improve productivity.

Scholars apply this resource-based theory as a foundation in the IS context through the notion of single IT resources, sets of IT resources and IT capabilities (Wade and Hulland, 2004; Bhatt and Grover, 2005). Hence, the RBV has gained considerable research interest over the past twenty years and provides valuable ways for information systems (IS) research to think about how IT contributes to firm performance and how to create value (Wade and Hulland, 2004).

The central premise of the RBV within the context of IT is that only investing in IT is insufficient to enhance competitive performance (Caldeira and Ward, 2003; Wade and Hulland, 2004). Instead, recent studies acknowledge that the process of leveraging IT resources in combination with other organisational asset and resources is a source of competitive benefits and value creation (Pavlou and El Sawy, 2006; Van de Wetering et al., 2018; Kim et al., 2011; van de Wetering, 2018a). We follow this so-called 'resource-based' line of reasoning and argue that a hospital's IT infrastructure – that is both flexible and supports collaboration functionality – is deemed appropriate to target IT resources to efficiently exchange health information and data within and between hospitals.

2.2 Flexible collaboration infrastructure

Extant literature proposed that IT infrastructure flexibility is a new competitive strategic asset that determines the value of that infrastructure to organisations (Byrd and Turner, 2000). The recent scholarly contributions also contend that modern digital business strategies focus on capability-building and leveraging IT investments (Bharadwaj et al., 2013; Setia et al., 2013; Sambamurthy et al., 2003; Van de Wetering et al., 2017b). Moreover, some scholars even argue that strategic investments in the firm's flexible IT infrastructure with the necessary assets and resources are deemed necessary to develop firm-wide capabilities to gain performance enhancements and IT business value (El Sawy and Pavlou, 2008; Mithas et al., 2012).

IT flexibility supports organisations to get sustained organisational advantage and even accommodates frequent business change, albeit to some extent (Mikalef et al., 2016; Van de Wetering et al., 2017c; Tafti et al., 2013). Extant literature shows that IT can be beneficial for hospitals regarding patient value, hospital performance gains and enhancements (Blumenthal, 2010; Buntin et al., 2011). Although flexible IT infrastructures can efficaciously alter the way hospitals exchange information, it is conceivable – following the RBV theoretic lens – that this aspect without the presence of complementary networking and collaboration assets, resources and capabilities is not sufficient to enable the process of HIDE. Collaborating organisations have become the 'new normal' in current dynamic markets to innovate, change and collaborate (Grefen, 2013). Within the literature on collaborative networks, information sharing is hardly addressed and mostly taken for granted, while these types of collaborations typically require fine-grained harmonisation between resources (Grefen, 2013; Bagheri et al., 2016). IT-enabled collaborative capabilities form a foundation for an organisation's ability to improve boundary spanning capabilities (Dewett and Jones, 2001; Gnyawali and Park, 2011) and thus also the exchange of data resources. Synthesising from the above, we see the value and contribution of FCI in facilitating cross-enterprise HIDE. Following Weill and Vitale (2002), Duncan (1995), Broadbent et al. (1999), Camarinha-Matos et al. (2009), Österle et al. (2012), Byrd and Turner (2000), van de Wetering et al. (2017a) and Termeer and Bruinsma (2016), we represent FCI through two core dimensions, i.e.,

1 IT flexibility

2 collaborative networking assets.

We expect that the process of exchanging health information mainly depends on

a The ability to flexibly anticipate on changes in circumstances and context.

b The ability of interaction and collaboration with other providers, like other hospitals, external general practitioners, external specialists, and health care providers, even in other countries.

Hospitals are becoming more aware that HIDE and other types of IT-enabled innovations promote patient, clinical as well as add social and organisational value by extending organisational boundaries and collaborating with multiple entities. Hence, we define:

Hypothesis 1 FCIs within hospitals positively influences HIDE.

2.3 Security and privacy

Conditions under which IT infrastructure capabilities and FCIs in particular add value have been a subject of much debate. Despite the enormous potential gains, there could be obstacles that impair the diffusion of IT, its adoption, usage, and performance contributions. Among those barriers are the perceived threats to the security and privacy of patients' health information and data (Sahama et al., 2013). Therefore, many countries around the world now working on legislative regulation of HIDE (in Europe: GDPR). In the meantime, adequate security measures and procedures within hospitals could contribute to confidentiality, integrity, availability, and timeliness of health information and patient's data (Sahama et al., 2013; Benharref and Serhani, 2014; Fedorowicz and Ray, 2004). However, much ambiguity remains concerning the influence of security measures on HIDE. Securing sensitive health data is an enormous challenge. It is in this process that we foresee that hospitals that heavily invest in security and privacy measures will be better equipped to facilitate HIDE. Hence, we propose:

Hypothesis 2 The degree to which hospitals deploy security measures – to protect patient data stored and transmitted by the hospital's IT system – influences the strength of the relationship between the FCI and HIDE.

3 Material and methods

To reach our main study objectives, we follow a deductive approach. Therefore, we base claims in theory and also focus on the development of persuasive arguments to substantiate our claims. To do so, we need a substantial amount of cross-sectional data from hospitals to test the two hypotheses.

3.1 Design and sample

To test the theorised relationships of our research model, it is essential that we obtain a significant amount of cross-sectional data from hospitals. For this, we found a unique and large-scale dataset, the European Hospital Survey: Benchmarking deployment of e-Health services (2012–2013). This particular dataset contains data from roughly 1,800 European hospitals across 30 countries and is distributed by the European Commission.[1]

In this survey, data were obtained from a representative sample of European acute hospitals to benchmark their level of e-Health and medical IT deployment and take-up of ICT and e-Health applications. Therefore, the survey categories and questions and cover a wide range of aspects from IT infrastructure, IT applications, exchange of health data and information, and security and privacy issues. Initial pilots contributed to the quality of the survey. The final questionnaire was in most cases completed by chief information officers (CIOs), IT managers (directors) and Chief Operating Officer (COO)/Operations Manager.

We performed Harman's single factor test using SPSS v24 on the included constructs in our study to control for common method bias (CMB). In doing so, we included the relevant constructs in the analysis and found that one specific factor could not attribute to the majority of variance (Podsakoff et al., 2003). Therefore, our data and results are not affected by CMB.

EMRs integrate a wide variety of modules and IT components within the hospital enterprise to integrally and centrally collect, store and distribute patient health information (DesRoches et al., 2013). We only focus on those particular hospitals in our dataset that use EMRs for HIDE, and this either through

1 a hospital-wide EMR (shared by all clinical service departments)

2 multiple local/departmental EMR systems which share information with a central EMR.

We base this selection strategy on several factors. First, extant scholarship argues that a high reach of IT within organisations (e.g., enterprise-wide reach of EMRs in hospitals) is tightly associated with both the design and implementation of business operations that tie activities and information flows across the organisation and beyond its boundaries (Sambamurthy et al., 2003; Van de Wetering, 2018b). There could be many types of EMR implementations each having different implementation features.

Notwithstanding, many EMRs offer key benefits to the quality of care through improved documentation and communication processes, like HIDE processes (Kazley and Ozcan, 2008). Furthermore, it only seems logical and conceivable that hospitals that do not use EMRs for information exchange are less likely to invest in security measures to enable HIDE or even to enhance HIDE in the hospital ecosystem. This notion is strengthened even more because modern EMRs typically have built-in safeguards features.

Thus, based on the concepts within our research model, the scope of our research, and to govern the data quality (due to missing values), we conservatively removed 768 cases. We included 983 hospitals in the final analyses representing most European countries.

3.2 Items and constructs

Each of the included operationalised latent constructs in our study are inspired based on past empirical and validated work. IT flexibility can be broadly considered as the degree of decomposition of an organisation's IT portfolio into loosely coupled subsystems that communicate through standardised interfaces (Byrd and Turner, 2000; Mikalef et al., 2016). Accordingly, we operationalised this quality through

1 The degree of standardisation – referring to established standards/policies on how applications connect and interoperate with each other (Weill and Ross, 2005).

2 The degree to which applications are integrated. Standardisation and thus also the standards the hospitals' systems support or comply with (e.g., HL7, IHE integration profiles, DICOM) and system integration are vital for HIDE to achieve its goal.

We adopt two critical indicators for hospital's collaborative networking assets, i.e.,

1 Hospitals' reach of a computer system (from personal computers that are not part of a hospital-wide system toward systems are part of regional or national networks as reach refers to locations) (Dewett and Jones, 2001; Termeer and Bruinsma, 2016; Broadbent et al., 1999).

2 The degree to which also patients – as an important stakeholder in this context – have online access to their records (Kruse et al., 2015).

Finally, we operationalised HIDE as a latent construct containing the following measures 12 measurements.[2]

All items were measured on or rescaled to a Likert scale from 1 to 5 (not in place – fully implemented), apart from our moderating variable security measures. We operationalised[3] security measures using a binary scale based on theoretically appealing cut-points (Sauer and Dick, 1993, Baron and Kenny, 1986). Therefore, group 1 ($N = 482$) represents low-security measures (cumulative scores 1 and 2) and group 2 ($N = 501$) represents high-security measures (cumulative scores 3 to 6). Together, they form representative groups of equal size. This study incorporates the control variable 'hospital type'.

4 Results

We use partial least squares (PLS)-SEM to assess our research model (Hair et al., 2016). PLS-SEM is a mature variance-based approach that has undergone severe methodological and theoretical examinations and has been the target of constructive scientific debates (Henseler et al., 2016). Hence, we estimate our model's parameters using SmartPLS version 3.2.7 (Ringle et al., 2015). We propose a reflective measurement model (mode A) for both the first and second-order constructs. For this study, we used 5,000 replications within the bootstrapping procedure to obtain stable results and to interpret the structural model. As for sample size requirements, the included data exceeds all minimum requirements.

4.1 Outer model assessment

We assessed the reliability of the outer model for the construct and item level. Reliability at the construct level was performed by examining the composite reliability (CR) scores and established that their values were above the threshold of 0.70 (Nunnally and Bernstein). Furthermore, we assessed the obtained construct-to-item loadings. Hence, following (Fornell and Bookstein, 1982) we removed all manifest indicators with loading of less than 0.6 from our model. In total, we removed six indicators (i.e., no. 1, 2, 4, 10, 11, and 12) from the HIDE construct.

Next, to reliability assessments, researchers should evaluate their measurement models by their convergent and discriminant validity (Hair et al., 2016; Fornell and Larcker, 1981; Campbell and Fiske, 1959). We analysed the average variance extracted (AVE), i.e., the average variance of measures accounted for by the latent construct to assess convergent validity. The lowest AVE value is 0.550, and that still exceeds the lower limit of 0.50 (Fornell and Larcker, 1981).

Discriminant validity concerns the extent to which constructs are genuinely distinct from other constructs by empirical standards (Hair et al., 2016). We assessed discriminant validity through different, but related tests. First, we checked for cross-loadings on other constructs (Farrell, 2010). Second, we investigated if the square root of the AVEs of all constructs is larger than the cross-correlation (Chin, 1998). All correlations among all constructs were below the threshold (0.70) (Fornell and Larcker, 1981). Third, and finally, we employed the heterotrait-monotrait (HTMT) ratio of correlations approach by Henseler et al. (2015) that showed acceptable outcomes.

Based on these outcomes, we established adequate convergent and discriminant validity. Table 1 shows the primary outcomes of the reliability, convergent and discriminant validity assessments of our model.

Table 1 Assessment of reliability, convergent and discriminant validity of reflective constructs

	1	*2*	*3*
1 Collaborative networking assets	*0.751*		
2 IT flexibility	0.277	*0.781*	
3 Health information exchange	0.272	0.396	*0.742*
AVE	0.564	0.610	0.550
Composite reliability	0.721	0.757	0.879

4.2 Hypotheses testing and uncovering heterogeneity issues

We estimated and validated the inner model, i.e., the structural model and the relationship among its constructs to analyse the hypotheses. Outcomes reveal that FCI is significantly related to HIDE (β = 0.433; t = 16.795; p < 0.0001). Moreover, the coefficient of determination (R^2) explains 18.3% of the variance for HIDE (R^2 = 0.181) with the control variable 'hospital type' showing a non-significant effect on HIDE (β = –0.040, t = 1.342, p = 0.180). These outcomes confirm our first hypothesis that hospitals' FCI positively influences HIDE.

To test, if security measures have conditioning (i.e., moderating) impact on the relation between FCI and HIE; we performed a non-parametric multi-group analysis (PLS-MGA) (Henseler et al., 2009). Henceforth, we divided our sample into two separate groups (Hair et al., 2016): group 1 (N = 482) with a low level of security measures and group 2 (N = 501) with a high degree of deployed security measures within the hospital. This subgroup approach is widely used in regression-based approaches to test the effects of categorical moderating variables (Baron and Kenny, 1986). We estimated the model for these two groups separately following Henseler et al. (2009).

Group differences are significant (at the 5% probability of error level) within this procedure if the obtained p-value is ≤ 0.05 or ≥ 0.95 for the focal path, regression coefficients. Hence, analyses show a statistically significant difference (p = 0.971) between group one and two. For group one (low-level of security) we see a significantly lower impact on HIDE by FCI (β = 0.346, t = 8.460, p < 0.001). The model run for this particular group explains 11.7% of the variance for HIE. Group two (high-level of security), on the other hand, shows a significantly stronger effect, i.e., (β = 0.451, t = 13.067, p < 0.001). More so, the model's inner model for group two has an R^2 = 0.195. These obtained outcomes confirm our second hypothesis.

Next, we controlled for possible unobserved heterogeneity within these two subgroups by employing the finite mixture (FIMIX) PLS procedures (Sarstedt and Ringle, 2010). Therefore, we segmented the subgroups into two to five segments (s2–s5) and ran separate analyses. Segmentation results do confirm that there indeed are factors that are currently not included in our analysis which might explain differences in coefficients of determination (up to $R^2 = 0.335$ for the high-security group; a maximum $R^2 = 0.135$ for the low-security group) across various hospital groups. Such a comprehensive FIMIX analysis is beyond our current scope.

Finally, to evaluate the overall predictive relevance of our model, we performed Stone-Geisser's test using the blindfolding procedure in SmartPLS version 3.2.7 (Ringle et al., 2015). All case Q^2 values for the single endogenous construct (for both communality and redundancy measures) were above the threshold value of zero, thereby indicating predictive relevance.

5 Discussion, conclusions and limitations

Drawing on the RBV, our current study investigated the degree to which FCI drives HIDE within hospitals. For this, we used a unique cross-sectional survey distributed by the European Commission containing data from all European hospitals. From literature, we know that HIDE is a promising technology-driven approach to improve resource utilisation, and quality of healthcare delivery (Vest et al., 2013). We, thus, also argued that hospitals that are equipped with an FCI would display enhanced levels of HIDE. This result is mainly so, due to hospitals' ability to flexibly anticipate changes in circumstances and context and their ability of interaction and collaboration with other providers. We also corroborated that the enhanced levels of HIDE would be even stronger for a hospital that have deployed security measures.

Outcomes of our analyses empirically support our claim and hypothesis that hospitals can enable HIDE through the use of FCIs. Furthermore, as substantiated by PLS-MGA analyses, hospitals' FCIs can be exploited even more to facilitate the process of information sharing through the deployment of a range of security measures.

With these outcomes, we make various contributions that improve our theoretical understanding of the role of FCIs in hospital enterprise. First, we contribute to the current knowledge base on HIDE by demonstrating the enabling effect of an FCI. Our results confirm past and recent claims made about the enabling role of flexible infrastructure configurations (Byrd and Turner, 2000; Bhatt and Grover, 2005; Kung et al., 2016). However, our study now shows that crucial role in the context of HIDE. Second, we extend recent conceptual literature (Benharref and Serhani, 2014; Sahama et al., 2013) by showing – using empirical data of 983 European hospitals – the conditioning role of deployed security measures in the process of exchanging health data. We, thus, showed which conditions need to be in place to complement an FCI and to leverage such a capability strategically. Outcomes also reveal that there are understudied synergy effects between infrastructural, technical and organisational design choices that hospitals need to make in the context of HIDE.

These current insights should be interpreted with caution as governmental agencies in various countries may regulate HIDE and thus also hospitals' range of possibilities and opportunities to develop and deploy HIDE. Notwithstanding, from a practical relevance perspective, the outcomes of this study provide several relevant implications for IT, business managers and other decision-makers within the hospital enterprise. First, we believe that these results can help the decision-makers in the process of efficiently allocating resources, and make purposeful IT investments to facilitate HIDE within the hospital enterprise. The results highlight the importance of actively investing in FCIs since they allow hospitals to be less rigid in the context of rapidly changing environments and promote rapid interaction and collaboration with other providers when the need or opportunity arises. In doing so, IT and business managers should focus capitalising on IT investments by focusing on the core aspects of FCIs as denoted by its underlying dimensions, i.e., collaborative networking assets and IT flexibility. Hence, hospitals should assess the current level of maturity of these particular dimensions, so that investments can be leveraged strategically. The IT flexibility dimension is a driver for organisational advantage and accommodates frequent business change. These investments should be complemented by allocating resources to enhance complementary networking and collaboration assets, resources and capabilities. Ultimately, this should lead to hospitals' ability to improve boundary spanning capabilities and the efficient exchange of health information and data within and between hospitals. The preceding discussion relates well to core argument that a flexible IT infrastructure will be of particular value if leveraged appropriately to support or enable critical organisational capabilities that work towards dynamic strategic alignment (Chung et al., 2003; van de Wetering et al., 2017b). Second, investments in FCIs and security measures go hand-in-hand; they should not be approached in isolation so that synergy effects cannot be achieved in practice. Thus, these particular investments should be in alignment. The competences and skills from different business and IT experts need to be synchronised to address obstacles that impair the diffusion of FCIs and form a threat to the security and privacy of patients' health information and data. Thus, IT, business and medical representatives should be simultaneously engaged in the process of building, integrating, and reconfiguring the IT infrastructure to enhance the collaboration process with multiple entities (e.g., providers, general practitioners, external specialists).

Some limitations constrain this study that future research should seek to address. Our FIMIX results indicate that various homogeneous sub-groups can explain higher levels of R^2 for HIDE. Future research could focus on a configurational approach (Meyer et al., 1993) through which researchers can compare groups and (sub)segments in detail. A good starting point would be looking at, e.g., the degree of IT investments, organisation size, and other potentially related digital capabilities (such as the capability to process information or telehealth). Hence, research could then refine our work so that we can advance our understanding of HIDE even further.

To conclude, it nearly goes without saying that HIDE is crucial for modern hospitals that operate in turbulent networked business ecosystems. Well deployed HIDE allows hospitals to enhance processes, efficiencies, and patient outcomes further. This current study specifically investigated the hypothesised relationship between the hospital's FCI and HIDE. Outcomes substantiate our claim that hospitals should invest in FCIs. Also, decision-makers should also benefit from a critical insight from our study, i.e., security measures to protect patient data, actually facilitate the process of HIDE. The outcomes of this study are, therefore, valuable for practice and the academic community.

References

Ahovuo, J., Tolkki, O., Fyhr, N. and Kujala, J. (2004) 'Process oriented organisation in the regional PACS environment', *EuroPACS-MIR 2004 in the Enlarged Europe*, pp.481–484.

Amit, R. and Schoemaker, P.J. (1993) 'Strategic assets and organizational rent', *Strategic Management Journal*, Vol. 14, No. 1, pp.33–46.

Bagheri, S., Kusters, R. J., Trienekens, J.J. and van der Zandt, H.V. (2016) 'Classification framework of knowledge transfer issues across value networks' *Procedia CIRP*, Vol. 47, pp.382–387 [online] https://research.tue.nl/en/publications/classification-framework-of-knowledge-transfer-issues-across-valu.

Barney, J. (1991) 'Firm resources and sustained competitive advantage', *Journal of Management*, Vol. 17, No. 1, pp.99–120.

Baron, R.M. and Kenny, D.A. (1986) 'The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations', *Journal of Personality and Social Psychology*, Vol. 51, No. 6, p.1173.

Begole, J., Rosson, M.B. and Shaffer, C.A. (1999) 'Flexible collaboration transparency: supporting worker independence in replicated application-sharing systems', *ACM Transactions on Computer-Human Interaction (TOCHI)*, Vol. 6, No. 2, pp.95–132.

Benharref, A. and Serhani, M.A. (2014) 'Novel cloud and SOA-based framework for e-health monitoring using wireless biosensors', *IEEE Journal of Biomedical and Health Informatics*, Vol. 18, No. 1, pp.46–55.

Bharadwaj, A., El Sawy, O., Pavlou, P. and Venkatraman, N. (2013) 'Digital business strategy: toward a next generation of insights', *MIS Quarterly*, June, Vol. 37, No. 2, pp.471–482.

Bhatt, G.D. and Grover, V. (2005) 'Types of information technology capabilities and their role in competitive advantage: an empirical study', *Journal of Management Information Systems*, Vol. 22, No. 2, pp.253–277, DOI: 10.1080/07421222.2005.11045844.

Blumenthal, D. (2010) 'Launching hitech', *New England Journal of Medicine*, Vol. 362, pp.382–385, DOI: 10.1056/NEJMp091282.

Broadbent, M., Weill, P. and Neo, B-S. (1999) 'Strategic context and patterns of IT infrastructure capability', *The Journal of Strategic Information Systems*, Vol. 8, No. 2, pp.157–187.

Brynjolfsson, E. and Hitt, L.M. (2000) 'Beyond computation: information technology, organizational transformation and business performance', *The Journal of Economic Perspectives*, Vol. 14, No. 4, pp.23–48.

Buntin, M.B., Burke, M.F., Hoaglin, M.C. and Blumenthal, D. (2011) 'The benefits of health information technology: a review of the recent literature shows predominantly positive results', *Health Affairs*, Vol. 30, No. 3, pp.464–471.

Byrd, T.A. and Turner, D.E. (2000) 'Measuring the flexibility of information technology infrastructure: exploratory analysis of a construct', *Journal of Management Information Systems*, Vol. 17, No. 1, pp.167–208.

Caldeira, M.M. and Ward, J.M. (2003) 'Using resource-based theory to interpret the successful adoption and use of information systems and technology in manufacturing small and medium-sized enterprises', *European Journal of Information Systems*, Vol. 12, No. 2, pp.127–141.

Camarinha-Matos, L.M., Afsarmanesh, H., Galeano, N. and Molina, A. (2009) 'Collaborative networked organizations – concepts and practice in manufacturing enterprises', *Computers and Industrial Engineering*, Vol. 57, No. 1, pp.46–60.

Campbell, D.T. and Fiske, D.W. (1959) 'Convergent and discriminant validation by the multi-trait-multi-method matrix', *Psychological Bulletin*, Vol. 56, No. 2, p.81.

Carvalho, J.V., Rocha, Á., van de Wetering, R. and Abreu, A. (2019) 'A maturity model for hospital information systems', *Journal of Business Research*, Vol. 94, pp.388–399.

Chamberlin, E.H. (1937) 'Monopolistic or imperfect competition?', *The Quarterly Journal of Economics*, Vol. 51, No. 4, pp.557–580.

Chiasson, M., Reddy, M., Kaplan, B. and Davidson, E. (2007) 'Expanding multi-disciplinary approaches to healthcare information technologies: what does information systems offer medical informatics?', *International Journal of Medical Informatics*, Vol. 76, pp.S89–S97.

Chin, W. (1998) 'Issues and opinion on structural equation modeling', *Management Information Systems Quarterly*, March, Vol. 22, No. 1, pp.7–16.

Chung, S.H., Rainer Jr., R.K. and Lewis, B.R. (2003) 'The impact of information technology infrastructure flexibility on strategic alignment and application implementations', *The Communications of the Association for Information Systems*, Vol. 11, No. 1, p.44.

Curtright, J.W., Stolp-Smith, S.C. and Edell, E.S. (2000) 'Strategic performance management: development of a performance measurement system at the Mayo Clinic', *Journal of Healthcare Management*, Vol. 45, No. 1, pp.58–68.

Desroches, C.M., Charles, D., Furukawa, M.F., Joshi, M.S., Kralovec, P., Mostashari, F., Worzala, C. and Jha, A.K. (2013) 'Adoption of electronic health records grows rapidly, but fewer than half of US hospitals had at least a basic system in 2012', *Health Affairs*, DOI: 10.1377/hlthaff. 2013.0308.

Dewett, T. and Jones, G.R. (2001) 'The role of information technology in the organization: a review, model, and assessment', *Journal of Management*, Vol. 27, No. 3, pp.313–346.

Duncan, N.B. (1995) 'Capturing flexibility of information technology infrastructure: a study of resource characteristics and their measure', *Journal of Management Information Systems*, No. 2, pp.37–57.

El Sawy, O.A. and Pavlou, P.A. (2008) 'IT-enabled business capabilities for turbulent environments', *MIS Quarterly Executive*, Vol. 7, No. 3, pp.139–150.

Farrell, A.M. (2010) 'Insufficient discriminant validity: a comment on Bove, Pervan, Beatty, and Shiu (2009)', *Journal of Business Research*, Vol. 63, No. 3, pp.324–327.

Fedorowicz, J. and Ray, A.W. (2004) 'Impact of HIPAA on the integrity of healthcare information', *International Journal of Healthcare Technology and Management*, Vol. 6, No. 2, pp.142–157.

Fornell, C. and Bookstein, F. (1982) 'Two structural equation models: LISREL and PLS applied to consumer exit-voice theory', *Journal of Marketing Research*, Vol. 19, No. 4, pp.440–452.

Fornell, C. and Larcker, D. (1981) 'Evaluating structural equation models with unobservable variables and measurement error', *Journal of Marketing Research*, Vol. 18, No. 1, pp.39–50.

Gnyawali, D.R. and Park, B-J.R. (2011) 'Co-opetition between giants: collaboration with competitors for technological innovation', *Research Policy*, Vol. 40, No. 5, pp.650–663.

Grefen, P. (2013) 'Networked business process management', *International Journal of IT/Business Alignment and Governance (IJITBAG)*, Vol. 4, No. 2, pp.54–82.

Hair Jr., J.F., Hult, G.T.M., Ringle, C. and Sarstedt, M. (2016) *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, Sage Publications, Los Angeles.

Hendrikx, H., Pippel, S., van de Wetering, R. and Batenburg, R. (2013) 'Expectations and attitudes in e-Health: a survey among patients of Dutch private healthcare organizations', *International Journal of Healthcare Management*, Vol. 6, No. 4, pp.263–268.

Henseler, J., Hubona, G. and Ray, P.A. (2016) 'Using PLS path modeling in new technology research: updated guidelines', *Industrial Management and Data Systems*, Vol. 116, No. 1, pp.2–20.

Henseler, J., Ringle, C.M. and Sinkovics, R.R. (2009) 'The use of partial least squares path modeling in international marketing', in *New Challenges to International Marketing*, pp.277–319, Emerald Group Publishing Limited.

Henseler, J., Ringle, C.M. and Sarstedt, M. (2015) 'A new criterion for assessing discriminant validity in variance-based structural equation modeling', *Journal of the Academy of Marketing Science*, Vol. 43, No. 1, pp.115–135.

Hersh, W.R., Totten, A.M., Eden, K.B., Devine, B., Gorman, P., Kassakian, S.Z., Woods, S.S., Daeges, M., Pappas, M. and McDonagh, M.S. (2015) 'Outcomes from health information exchange: systematic review and future research needs', *JMIR Medical Informatics*, Vol. 3, No. 4, p.e39.

Hulland, J. (1999) 'Use of partial least squares (PLS) in strategic management research: a review of four recent studies', *Strategic Management Journal*, Vol. 20, No. 2, pp.195–204.

Kazley, A.S. and Ozcan, Y.A. (2008) 'Do hospitals with electronic medical records (EMRs) provide higher quality care? An examination of three clinical conditions', *Medical Care Research and Review*, Vol. 65, No. 4, pp.496–513.

Kim, G., Shin, B., Kim, K.K. and Lee, H.G. (2011) 'IT capabilities, process-oriented dynamic capabilities, and firm financial performance', *Journal of the Association for Information Systems*, Vol. 12, No. 7, p.487.

Kohli, R. and Tan, S.S-L. (2016) 'Electronic health records: how can IS researchers contribute to transforming healthcare?', *MIS Quarterly*, Vol. 40, No. 3, pp.553–573.

Konsynski, B.R. and Mcfarlan, F.W. (1990) 'Information partnerships – shared data, shared scale', *Harvard Business Review*, Vol. 68, No. 5, pp.114–120.

Kruse, C.S., Bolton, K. and Freriks, G. (2015) 'The effect of patient portals on quality outcomes and its implications to meaningful use: a systematic review', *Journal of Medical Internet Research*, Vol. 17, No. 2, p.e44.

Kung, L., Wang, Y. and Kung, H-J. (2016) 'Exploring configurations for business value from event-driven architecture in healthcare', in *Proceedings of the Thirty Seventh International Conference on Information Systems*, Ireland, Dublin, pp.1–11.

Lee, J., Mccullough, J.S. and Town, R.J. (2013) 'The impact of health information technology on hospital productivity', *The RAND Journal of Economics*, Vol. 44, No. 3, pp.545–568.

Lotfi, Z., Mukhtar, M., Sahran, S. and Zadeh, A.T. (2013) 'Information sharing in supply chain management', *Procedia Technology*, Vol. 11, pp.298–304.

Lyytinen, K., Yoo, Y. and Boland Jr., R.J. (2016) 'Digital product innovation within four classes of innovation networks', *Information Systems Journal*, Vol. 26, No. 1, pp.47–75.

Makadok, R. (2001) 'Toward a synthesis of the resource-based and dynamic-capability views of rent creation', *Strategic Management Journal*, Vol. 22, No. 5, pp.387–401.

Mcglynn, E., Asch, S., Adams, J., Keesey, J., Hicks, J., Decristofaro, A. and Kerr, E. (2003) 'The quality of health care delivered to adults in the United States', *New England Journal of Medicine*, Vol. 348, No. 26, pp.2635–2645.

Meyer, A.D., Tsui, A.S. and Hinings, C.R. (1993) 'Configurational approaches to organizational analysis', *Academy of Management Journal*, Vol. 36, No. 6, pp.1175–1195.

Mikalef, P., Pateli, A. and van de Wetering, R. (2016) 'IT flexibility and competitive performance: the mediating role of IT-enabled dynamic capabilities', *24th European Conference on Information Systems (ECIS).*

Mithas, S., Tafti, A. and Mitchell, W. (2013) 'How a firm's competitive environment and digital strategic posture influence digital business strategy', *MIS Quarterly*, June, Vol. 37, No. 2, pp.511–536.

Mithas, S., Tafti, A.R., Bardhan, I. and Goh, J.M. (2012) 'Information technology and firm profitability: mechanisms and empirical evidence', *MIS Quarterly*, Vol. 36, No. 1, pp.205–224.

Nunnally, J. and Bernstein, I. (1994) *Psychometric Theory*, McGraw-Hill, New York, NY.

Österle, H., Fleisch, E. and Alt, R. (2012) *Business Networking: Shaping Enterprise Relationships on the Internet*, Springer Science & Business Media, New York.

Overby, E., Bharadwaj, A. and Sambamurthy, V. (2006) 'Enterprise agility and the enabling role of information technology', *European Journal of Information Systems*, Vol. 15, No. 2, pp.120–131.

Patel, V., Abramson, E.L., Edwards, A., Malhotra, S. and Kaushal, R. (2011) 'Physicians' potential use and preferences related to health information exchange', *International Journal of Medical Informatics*, Vol. 80, No. 3, pp.171–180.

Pavlou, P.A. and El Sawy, O.A. (2006) 'From IT leveraging competence to competitive advantage in turbulent environments: the case of new product development', *Information Systems Research*, Vol. 17, No. 3, pp.198–227.

Podsakoff, P.M., Mackenzie, S.B., Lee, J-Y. and Podsakoff, N.P. (2003) 'Common method biases in behavioral research: a critical review of the literature and recommended remedies', *Journal of Applied Psychology*, Vol. 88, No. 5, p.879.

Ringle, C.M., Wende, S. and Becker, J-M. (2015) *SmartPLS 3*, SmartPLS GmbH, Boenningstedt [online] http://www.smartpls.com (accessed 5 September 2018).

Runyon, B. and Pessin, G. (2017) *Hype Cycle for Real-Time Health System Technologies*, July, Gartner [online] https://www.gartner.com/en/documents/3762663/hype-cycle-for-real-time-health-system-technologies-2017 (accessed 1 March 2018).

Sahama, T., Simpson, L. and Lane, B. (2013) 'Security and privacy in e-Health: is it possible?', *2013 IEEE 15th International Conference on e-Health Networking, Applications and Services (Healthcom)*, IEEE, pp.249–253.

Sambamurthy, V., Bharadwaj, A. and Grover, V. (2003) 'Shaping agility through digital options: reconceptualizing the role of information technology in contemporary firms', *MIS Quarterly* June, Vol. 27, No. 2, pp.237–263.

Sarstedt, M. and Ringle, C. (2010) 'Treating unobserved heterogeneity in PLS path modeling: a comparison of FIMIX-PLS with different data analysis strategies', *Journal of Applied Statistics*, Vol. 37, No. 8, pp.1299–1318.

Sauer, P.L. and Dick, A. (1993) 'Using moderator variables in structural equation models', in McAlister, L. and Rothschild, M.L. (Eds.): *NA – Advances in Consumer Research*, Vol. 20, pp.636–640, Association for Consumer Research, Provo, UT.

Setia, P., Venkatesh, V. and Joglekar, S. (2013) 'Leveraging digital technologies: how information quality leads to localized capabilities and customer service performance', *MIS Quarterly*, June, Vol. 37, No. 2, pp.565–590.

Sheikh, A., Sood, H.S. and Bates, D.W. (2015) 'Leveraging health information technology to achieve the 'triple aim' of healthcare reform', *Journal of the American Medical Informatics Association*, Vol. 22, No. 4, pp.849–856.

Tafti, A., Mithas, S. and Krishnan, M.S. (2013) 'The effect of information technology-enabled flexibility on formation and market value of alliances', *Management Science*, Vol. 59, No. 1, pp.207–225.

Termeer, C.J. and Bruinsma, A. (2016) 'ICT-enabled boundary spanning arrangements in collaborative sustainability governance', *Current Opinion in Environmental Sustainability*, Vol. 18, pp.91–98.

van de Wetering, R. (2018a) 'IT-enabled clinical decision support: an empirical study on antecedents and mechanisms', *Journal of Healthcare Engineering*, Vol. 10, Article ID: 6945498, 10pp, https://doi.org/10.1155/2018/6945498.

van de Wetering, R. (2018b) 'IT infrastructure capability and health information exchange: the moderating role of electronic medical records' reach', in Paschke, W.A. (Ed.): *21st International Conference on Business Information Systems*, Springer, Berlin, Germany.

van de Wetering, R., Mikalef, P. and Helms, R. (2017a) 'Driving organizational sustainability-oriented innovation capabilities: a complex adaptive systems perspective', *Current Opinion in Environmental Sustainability*, Vol. 28, pp.71–79.

van de Wetering, R., Mikalef, P. and Pateli, A. (2017b) 'Managing firms' innovation capabilities through strategically aligning combinative IT and dynamic capabilities', *23rd third Americas Conference on Information Systems*, Boston, USA.

van de Wetering, R., Mikalef, P. and Pateli, A. (2017c) 'A strategic alignment model for IT flexibility and dynamic capabilities: toward an assessment tool', *25th European Conference on Information Systems (ECIS)*, Guimarães, Portugal, 5–10 June, pp.1468–1485.

van de Wetering, R., Versendaal, J. and Walraven, P. (2018) 'Examining the relationship between a hospital's IT infrastructure capability and digital capabilities: a resource-based perspective', *24th Americas Conference on Information Systems (AMCIS)*, AIS, New Orleans, 16–18 August.

Vest, J.R., Campion, T.R., Kaushal, R. and Investigators, H. (2013) 'Challenges, alternatives, and paths to sustainability for health information exchange efforts', *Journal of Medical Systems*, Vol. 37, No. 6, p.9987.

Wade, M. and Hulland, J. (2004) 'Review: the resource-based view and information systems research: review, extension, and suggestions for future research', *MIS Quarterly*, Vol. 28, No. 1, pp.107–142.

Walker, J., Pan, E., Johnston, D., Adler-Milstein, J., Bates, D.W. and Middleton, B. (2005) 'The value of health care information exchange and interoperability: there is a business case to be made for spending money on a fully standardized nationwide system', *Health Affairs*, Vol. 24, Suppl. 1, p.W5-10.

Weill, P. and Ross, J. (2005) 'A matrixed approach to designing IT governance', *MIT Sloan Management Review*, Vol. 46, No. 26, pp.26–34.

Weill, P. and Vitale, M. (2002) 'What IT infrastructure capabilities are needed to implement e-business models?', *MIS Quarterly*, Vol. 1, No. 1, p.17.

Weill, P., Subramani, M. and Broadbent, M. (2002) 'Building IT infrastructure for strategic agility', *MIT Sloan Management Review*, Vol. 44, p.57.

Notes

1 This dataset was distributed by the European Commission and is freely accessible through: https://ec.europa.eu/digital-single-market/en/news/european-hospital-survey-benchmarking-deployment-ehealth-services-2012-2013.

2
- a patient interaction
- b make appointments at other care providers
- c send/receive referral and discharge letters
- d transfer prescriptions to pharmacists
- e exchange medical patient data
- f receive laboratory reports
- g share them with other healthcare professionals
- h exchange patient medication lists with healthcare professionals/providers
- i exchange radiology reports
- j exchange medical patient data
- k certify sick leaves
- l certify disabilities.

3 This question contained multiple possible answers

   a encryption of stored data
   b encryption of transmitted data
   c workstations with access through health professional cards
   d workstations with access through fingerprint information
   e workstations with access through a password
   f data entry certified with digital.

4 An even more liberal threshold is a loading value of 0.4 for exploratory studies, see Hulland (1999).