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The Relative Role of Digital Complementary Assets and Regulation in Discontinuous Telemedicine Innovation in European Hospitals

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ABSTRACT

Telemedicine innovation is important for accelerating the digital transformation of the health care sector. However, telemedicine is a discontinuous digital innovation, and incumbent health care organizations are lagging in its adoption. We combine research on IT innovation adoption and discontinuous innovation to study the relative role of two drivers of discontinuous innovation adoption: digital complementary assets and the regulatory environment. Our findings from 1,753 acute care hospitals across 30 European countries suggest that digital complementary assets have a stronger effect on telemedicine innovation adoption than the regulatory framework. In addition, we observe application- and business model-specific differences. Overall, our findings add the role of organizational versus regulatory drivers of discontinuous innovation adoption to information systems research, emphasize the importance of digital complementary assets for the adoption of discontinuous innovation by incumbent organizations, and provide new insights into how the diffusion of telemedicine innovation can be accelerated.

KEYWORDS

Digital complementary assets; regulation; digital transformation; digital innovations; discontinuous innovations; health care; innovation adoption; telemedicine

Introduction

Telemedicine is defined as the delivery of health care services by digital means where distance is a critical factor [109]. Telemedicine applications can bridge the distance between patient and provider or between providers, thus enabling an opportunity to reach rural or structurally weak areas. Telemedicine can therefore play an important role in improving access to and the quality of care in both developed and developing countries [85, 109]. Furthermore, many developed countries place considerable hope on digital applications as an effective means of cost containment and quality improvement [2, 26]. Yet, despite its supposed high potential, the diffusion of digital innovations (e.g., telemedicine) in health care was considerably slower and less smooth than in other service sectors, and incumbent health care organizations in particular are lagging in adoption [e.g., 2, 103].

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This is because telemedicine is different from the predominant direct and personal treatment in health care in that it represents a discontinuous change that requires new business models that are often in conflict with the established models of incumbent health care providers [e.g., 8, 14]. Exploring the organizational and regulatory drivers for the adoption of telemedicine applications thus represents a unique opportunity to study the determinants of the application of such new business models [e.g., 106] or value creation opportunities [e.g., 60, 89] for incumbent organizations in the context of digital transformation.

Telemedicine encompasses provider-to-provider as well as provider-to-patient interaction and thus employs B2B (business-to-business) as well as B2C (business-to-customer) business models. Common applications are (i) teleradiology, (ii) telemonitoring, (iii) teleconsultation with providers, and (iv) teleconsultation with patients (a detailed description of the applications is provided in Table 1). While provider-to-provider (or B2B) business models include the value co-creation [e.g., 29, 100] between highly trained professionals, the value co-creation in customer-facing provider-to-patient (or B2C) business models involves two very different groups (i.e., patients and health care professionals). As a result, the adoption of these two types of business models may be influenced in different ways. On the one hand, the two business models may rely on different key parts of the IT infrastructure (i.e., digital complementary assets). On the other hand, the regulatory environment may present divergent opportunities and challenges. Thus, a combined analysis of adoption determinants for B2B and B2C business models for digital innovations in health care can provide valuable insights for information systems (IS) literature. Especially teleradiology and telemonitoring present a major deviation from traditional care. While providers would sometimes consult with other providers or patients per phone or mail in the past, diagnosis and treatment decisions were solely provided face-to-face. Nevertheless, the speed and scope of access and the amount of information provided by teleconsultation applications present a discontinuity in the health care setting.

In this paper, we bridge the literatures on information technology (IT) innovation adoption and discontinuous innovation to explore the role of organizational and

Table 1. Types of telemedicine applications and their characteristics.

Type of Telemedicine Application	Characteristics
Teleradiology	Provider-to-provider application (B2B) Teleradiology is concerned with the transmission of digitized medical images (e.g., X-rays, CT scans, MRI scans, or sonograms) over electronic networks and with the interpretation of the transmitted images for diagnostic purposes
Telemonitoring	Provider-to-patient application (B2C) Telemonitoring enables the supervision of the patient by a health care provider. Vital data (e.g., blood pressure, weight, ECG) are sent to the health care provider by means of special devices
Teleconsultation with providers	Provider-to-provider application (B2B) Teleconsultation with providers is defined as consultation between health care providers using information and communication technology for the electronic transmission of medical examination data to obtain specialized knowledge or a second opinion
Teleconsultation with patients	Provider-to-patient application (B2C) Teleconsultations with patients constitute consultation by a health care provider using information and communication technology, generally for the purpose of diagnosis or treatment of a patient at a site remote from the health care provider

regulatory drivers, that is, digital complementary assets and the regulatory environment, in promoting the adoption of discontinuous digital innovations in incumbent organizations. This is relevant and different from exploring the drivers of other forms of IS innovation adoption because digital transformation is related to discontinuous changes that pose additional challenges to incumbent organizations [e.g., 89, 104, 106]. We build on the resource-based view of complementary assets and add the role of the regulatory framework to the study of the drivers of hospitals' adoption of telemedicine applications. In doing so, we address the following research question:

RQ : What is the relative role of digital complementary assets and the regulatory framework in the adoption of telemedicine applications by hospitals?

To answer our research question, we use a large-scale cross-sectional dataset that merges data from various sources on the role of complementary assets and the regulatory environment in the adoption of telemedicine applications by 1,753 acute care hospitals across 30 European countries. We further control for additional characteristics of the hospitals as well as national health care expenditures. We test four relevant telemedicine applications, that is, (i) teleradiology, (ii) telemonitoring, (iii) teleconsultation with providers, and (iv) teleconsultation with patients, and thereby distinguish between digital B2B and B2C services offered by the hospitals. Our findings from logistic regression models suggest that digital complementary assets have a more important effect on the adoption of telemedicine applications than the regulatory framework, especially in the context of B2B applications.

By studying the relative role of digital complementary assets and the regulatory environment in the adoption of discontinuous digital innovations, our research makes the following three contributions. First, we contribute to IS research on digital transformation by studying adoption determinants of discontinuous digital innovations within incumbent organizations in highly regulated industries such as health care. By exploring the relative role of organizational and regulatory factors in telemedicine adoption, we respond to the calls for research on digital transformation at multiple levels of analysis in IS literature [e.g., 39, 60, 104]. Second, our findings advance research on incumbents' responses to discontinuous innovation by further emphasizing the role of digital complementary assets as a means to maintain their competitive advantage and to counteract incumbents' inertia [36, 57, 91]. Third, we provide large-scale empirical evidence on the drivers of telemedicine adoption in health care [e.g., 55], which results in practical implications for health care providers and policy makers to help accelerate the hesitant digital transformation in the health care sector [e.g., 2, 103].

Literature Review: Digital Transformation and Digital Innovation Adoption in Incumbent Organizations

Digital transformation has become an increasingly studied and important phenomenon in IS research [7, 104, 106]. Recent research highlights the need for a better understanding of the determinants of digital transformation at multiple levels, especially the organizational and institutional level [e.g., 39, 60, 104]. Hinings et al. [39], for example, emphasize the importance of accounting for the relative effects of both organizational and institutional factors when researching digital transformation. In this sense, complementary assets might represent important organizational factors that drive digital innovations [81]. Institutional factors affecting innovation adoption in health care are typically related to the regulatory framework, which can promote or restrict innovation adoption [e.g., 9, 14].

Moreover, there is a minimal amount of empirical research on how digital transformation is achieved in incumbent organizations [e.g., 104, 106]. While much of the extant research on digital transformation is dedicated toward understanding how entrepreneurs leverage the opportunities of radical business model innovations [4, 106], how entrepreneurs build capabilities for digital transformation [52], or how new ventures may profit from organizational agility [12, 78, 90, 106], the important question of what drives established, incumbent organizations to adopt discontinuous digital innovations and respond to the opportunities and challenges of digital transformation has remained less explored [e.g., 104, 106].

Digital transformation is related to discontinuous changes that pose additional challenges to incumbent organizations. Discontinuous innovations typically include major changes in technologies, products, services, or programs that can create a new line of business that is new for both the organization and the market place. They therefore lead to new or the expansion of current markets that may not yet perceive a need for the novel product [e.g., 8, 99]. Incumbent organizations often struggle when confronted with discontinuous innovations and are less likely to adopt them because they have to deal with the legacies of the past and take diverse organizational and economic considerations into account [e.g., 89, 104, 106].

Recent IS literature increasingly pays attention to how IS research can contribute to innovation research, especially with regard to its focus on the adoption determinants of different forms of innovation [e.g., 27, 112]. In addition, the traditional view of IT as an operand resource (i.e., enabler of innovation) for innovation processes and innovation outcomes is shifting toward the role as an operant resource (i.e., trigger of innovation) that leads to innovation or value co-creation [58]. Fichman et al. [25] define digital innovation as a "product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT" [25, p. 330]. Digital innovation encompasses a concerted orchestration of new products, new services, new processes, or new business models [39, 50, 59, 94]. Digitization and digital innovations are often drivers of discontinuous change [e.g., 8, 82]. In this regard, discontinuous digital innovations can exert a large impact in both product- and service-oriented industries [54, 113]. Yet, authors seldom focused on digital transformation and digital innovations in the research field of discontinuous innovation [e.g., 8, 96]. In an environment that is progressively penetrated by digitization, incumbent organizations in particular will increasingly have to adapt to changes caused by discontinuous digital innovations. Thus, understanding the relative role of organizational and regulatory drivers of discontinuous digital innovation adoption in incumbent organizations represents an important, yet so far understudied, question.

Theory and Hypotheses

Role of Digital Complementary Assets in the Adoption of Discontinuous Digital Innovations

Incumbents need to balance the exploitation of existing capabilities while also building new capabilities that are compatible with extant path dependences [e.g., 89, 104]. These characteristics pose several challenges with respect to innovation capabilities, focus, collaboration, and governance that incumbents need to manage in order to balance new opportunities and established practices [89]. Taken together, these considerations can result in incumbents' delayed implementation of discontinuous digital innovations and entry into associated new subfields [57, 111, 114]. Yet, incumbents do not unavoidably fail at identifying and exploiting opportunities resulting from discontinuous innovations. Over time, they have been able to develop capabilities and resources that enable them to identify new opportunities better and make appropriate investments [38, 51]. This seems to be especially the case if they possess complementary assets for the commercialization of those innovations [73, 91, 95]. Therefore, the adaptability of incumbents facing technological change is influenced by their ability to leverage their complementary assets [e.g., 42, 91, 95]. In this context, specialized complementary assets are of greater relevance than generic ones because they are tailored to the specific innovation, whereas generic assets have multiple applications. Thus, specialized complementary assets grant a bigger advantage for the incumbent [91, 95]. These complementary assets enable organizations to avoid displacement in the face of discontinuous change and facilitate entry into partnerships, networks, and new markets or submarkets [38, 57, 91]. Furthermore, incumbents' performance with a discontinuous innovation is positively influenced by complementary assets [74]. Market knowledge, reputation, regulatory knowledge, client lists, marketing, service networks, and complementary technologies are examples of complementary assets [e.g., 91, 95]. When an innovation is systemic, as is the case with digital innovations, the complementary assets may be other parts of a system as well [91]. Therefore, digital technologies can also present complementary assets; more specific, they present digital complementary assets.

In this paper, digital complementary assets consist of complementary digital technologies that facilitate the use of a digital innovation and increase the value of its output. Thus, our conceptualization differs from that of Rosemann et al. [71] because we consider specialized digital complementary assets instead of general purpose assets. New technological innovations change products and services, yet they do not entail completely new customers. Thus, complementary assets are particularly valuable when the customer base does not substantially change [e.g., 72]. In a similar vein, extant literature argues that incumbents are less likely to be at a disadvantage in the face of a new technology when the technological change does not affect the existing value network [72].

Srinivasan et al. [84] found empirical evidence that if organizations possessed more complementary assets, they showed a higher level of technology adoption. The empirical findings of King and Tucci [47] and Hüsig et al. [41] also indicate that incumbents' experience in existing subfields and its complementary assets translate into higher innovation ability and therefore improve the motivation and the organizations' likelihood of entering new, related subfields because the perceived odds of successful adoption are better. This would suggest that the static experience and technological capabilities of the incumbents in existing markets and operations can lead to dynamic capabilities [92] that develop an absorptive capacity [15, 115] for acquiring new technologies to enter novel submarkets [41, 43]. Therefore, we expect that organizations faced with discontinuous innovations will have a higher probability of adopting the innovation and entering the respective submarket.

Finally, incumbents with digital complementary assets may have a higher affinity to discontinuous digital innovations, more experience, and a better understanding of their advantages because these organizations may perceive the characteristics of the innovation differently: they may experience the relative advantage, compatibility, trialability, and observability to be higher and the complexity to be lower. Thus, digital complementary assets can exhibit a positive impact on the innovation adoption process [70, 84, 95]. In addition, organizational agility can enable incumbents to detect opportunities for innovation and to seize market opportunities by assembling essential assets and knowledge. Thus, digital technologies that present complementary assets can facilitate incumbents' adaptation to digital transformation by contributing to their organizational agility [78, 104]. Accordingly, we propose in the case of incumbent hospitals and telemedicine:

Hypothesis 1: Incumbent hospitals that possess specialized digital complementary assets are more likely to adopt a discontinuous digital innovation such as telemedicine.

Role of the Regulatory Context in the Adoption of Discontinuous Digital Innovations

Particularly in highly regulated markets such as health care systems, the regulatory framework has been found to affect the adoption of innovations [e.g., 14, 18]. Hinings et al. [39] further emphasize the role of regulatory pressures in the digital age. Especially if digital innovations challenge institutional arrangements on the field level (e.g., in the case of health care the change from direct treatment to digital interaction, diagnosis, and suggestions), these changes might face significant issues as they are not aligned with current regulation. European health care systems are dominated by the public sector and mostly financed by taxes (national health service model) or compulsory health insurance plans (social insurance model) [16]. Therefore, regulations issued by policy makers cause regulatory pressures that are highly relevant for health care providers such as hospitals. On the other hand, digital transformation may also compel policy makers such as government agencies to rethink the laws, regulations, and policies related to a wide range of issues such as data privacy and security, liability, or financing [60].

The existence of regulation can facilitate the adoption of discontinuous innovation by reducing uncertainty and information asymmetries. Thus, a regulatory framework diminishes the perceived risk associated with the innovation [56, 61]. Regulation can promote digital innovations by facilitating knowledge deployment and by providing subsidies, standards, and an innovation directive [48, 107]. In the context of telemedicine, extant literature stresses the importance of the regulatory framework: suitable, supportive regulation may not only promote investments in and adoption of digital innovations but also encourage the trust of stakeholders in these innovations [e.g., 49, 87]. Thus, we argue:

Hypothesis 2a: The general existence of a regulatory framework for telemedicine has a positive influence on incumbent hospitals' propensity to adopt a discontinuous telemedicine innovation.

On the other hand, regulatory hindrances can also impede the adoption of discontinuous innovations in general [41, 107] and digital innovations in health care in particular [97]. This may be induced by either regulative requirements having to be fulfilled, causing daunting organizational accountability [e.g., 21, 41] or legal barriers that result from outmoded, unsuitable regulation that precludes innovation adoption [97]. In the context of telemedicine, the regulatory framework can consist of regulation that governs scope and responsibilities as well as security and privacy of data. Yet, regulation that imposes restrictions (such as the necessity of treatment in person) can pose a legal barrier that may cause organizations to circumvent this regulation by adopting applications to which the regulation does not apply [14]. These arguments thus lead to the following hypothesis:

Hypothesis 2b: The existence of regulation that imposes restrictions on the treatment of patients by telemedicine reduces incumbent hospitals' propensity to adopt provider-to-patient innovations and increases their propensity to adopt provider-to-provider innovations that circumvent this regulation.

Discontinuous innovations can differ significantly in the way they generate revenues and appropriate profits. Therefore, they may not be conform with incumbents' existing business models [e.g., 14, 62]. In addition, discontinuous innovations can cannibalize incumbents' current profits, leading to disincentives to invest in the innovation. Therefore, a regulatory framework that enables financial support is likely to be a driver for market entry and innovation adoption [30, 51]. Financial incentives, support by governments, and similar institutions have been identified as important drivers of innovation adoption [e.g., 32, 76]. We therefore postulate:

Hypothesis 2c: The existence of reimbursement regulation for telemedicine has a positive influence on incumbent hospitals' likelihood to adopt a discontinuous telemedicine innovation.

Our theoretical framework is summarized in Figure 1.

Research Context: The Digital Transformation of European Hospitals through Telemedicine

We tested our hypotheses in the context of European hospitals in the period from October 2012 to February 2013. European hospitals are facing external pressure to adopt discontinuous digital innovations such as telemedicine, and, at the same time, have to deal with an insufficient regulatory framework and technical issues [22, 23, 88]. Hence, the process of digitization is progressing only slowly in health care [e.g., 63, 67, 77, 103], and incumbents such as hospitals are often reluctant to change and adopt innovations, which often results in incumbent inertia. Although telemedicine is not likely to entirely replace traditional treatment, it increases the impact of the underlying digital

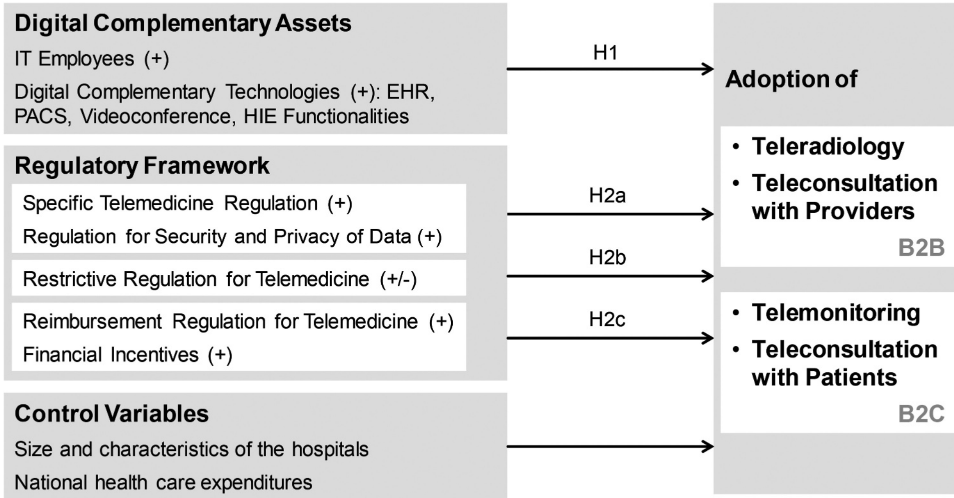

Figure 1. Conceptual research model.

technology and service in health care [75]. Thus, health care providers will have to adapt to digital transformation in this sector.

In the context of telemedicine, relevant digital complementary assets encompass health information technology (HIT) applications such as electronic health records (EHR), picture archiving and communication systems (PACS), videoconferencing facilities, and health information exchange (HIE) functionalities like the exchange of radiology reports, medical patient data, laboratory reports, and medication lists. These digital complementary assets facilitate the use of telemedicine, and increase the value of its output. In addition, IT employees can be complementary assets as well.

Hospitals operate in highly regulated environments in which public authorities play a crucial role [e.g., 77, 79]. Therefore, using European hospitals as the unit of analysis does not only enable us to measure the impact of organizational factors on the adoption of digital innovations in health care, but also to observe organization-level responses to governmental regulation [80]. National policies and regulations are divergent: European countries rarely possess a coherent set of laws specifically designed to address data security, privacy, confidentiality, and liability. Instead, most countries currently use the general legal framework (e.g., laws on patient rights and data protection) and regulations on professional conduct to regulate eHealth (electronic health) applications like telemedicine. Specific regulation is often still in the process of being drafted or enacted [e.g., 88]. Financial resources and reimbursement show a mixed picture: in European countries, the primary sources of funding are government or quasi-public sources (e.g., general budgets for health, dedicated information and communications technology (ICT) budgets, or special levies on statutory health insurances). Public budgets dedicated specifically to eHealth applications are still an exception; however, there is widespread use of project-based sourcing [88]. Thus, health care providers are facing significant uncertainty with regard to the regulatory context of eHealth applications. Nevertheless, the importance of eHealth for the European Commission and national governments puts pressure on established health care organizations to implement suitable applications.

In sum, the rise of eHealth applications like telemedicine in European health care systems provides a valuable setting for the investigation of the impact of regulatory and organizational factors on the adoption of discontinuous innovations in the face of institutional transition and digital transformation.

Data and Methodology

Data

Our study uses a cross-sectional design to analyze secondary data from various sources. We compiled our database with data from the *European Hospital Survey* which investigated the deployment of eHealth services [24] and data on regulation for telemedicine applications collected manually from national laws and ministries of health as well as from European Commission publications. Regulation data is lagged by two years. The sample contains 1,753 hospitals from the EU27 countries[1] and additionally from Croatia, Iceland, and Norway. Finally, data on national health expenditures was obtained from the Organisation for Economic Co-operation and Development (OECD).

Measures

An overview of all of the included variables is provided in Table 2 and described in more detail in the following sections.

Dependent variables

The analysis includes four binary dependent variables: the likelihood of incumbent's adoption of each of the four applications (1) teleradiology (B2B), (2) telemonitoring (B2C), or teleconsultation with (3) other health care practitioners (B2B) or (4) with patients (B2C), which is measured separately as a dependent variable. These four variables take respectively the value "1" if the hospital adopted *Teleradiology, Telemonitoring, Teleconsultation with Providers*, or *Teleconsultation with Patients*. The non-adoption of each variable is encoded with "0". By investigating the four applications separately, we are able to observe differences in the impact of the regulatory and organizational factors on each of the applications. This way, we can draw a more refined picture of telemedicine adoption and account for heterogeneities of applications.

Independent variables

In order to test the impact of the **regulatory framework** on the adoption probability of telemedicine applications, we included the following variables in our models: *Specific Telemedicine Regulation* (i.e., regulation on scope and responsibilities), *Restrictive Telemedicine Regulation* (i.e., the need for treatment in person), *Regulation for Security and Privacy of Data*, and *Reimbursement Regulation for Telemedicine* (i.e., existence of regulation for the compensation of hospitals for telemedicine services) are binary variables on a national level. Regulation that restricts the adoption of telemedicine consists of the need for treatment in person (Austria, Germany, and Poland). *Financial Incentives tied to IT Systems* also present a binary variable.

Table 2. Descriptive statistics for empirical model data.

	Variable	Description	Mean	SD	Min.	Max.
Dependent Variables	Teleradiology	1 = has adopted teleradiology	0.42	0.49	0.00	1.00
	Telemonitoring	1 = has adopted telemonitoring	0.14	0.35	0.00	1.00
	Teleconsultation with Providers	1 = has adopted teleconsultation with providers	0.32	0.47	0.00	1.00
	Teleconsultation with Patients	1 = has adopted teleconsultation with patients	0.15	0.35	0.00	1.00
Regulatory Framework	Specific Telemedicine Regulation	1 = specific telemedicine regulation exists Describes the scope of telemedicine services and responsibilities of health care providers	0.34	0.47	0.00	1.00
	Regulation for Security and Privacy of Data	1 = regulation for security and privacy exists	0.58	0.49	0.00	1.00
	Restrictive Telemedicine Regulation	1 = restrictive telemedicine regulation exists Describes the need for treatment in person: direct and personal treatment of the patient by the health care provider	0.25	0.43	0.00	1.00
	Reimbursement Regulation for Telemedicine	1 = reimbursement regulation exists Existence of regulation that governs the compensation of hospitals for telemedicine services	0.36	0.48	0.00	1.00
	Financial Incentives tied to IT Systems	1 = hospital receives financial incentives from health plans or other organizations that are tied to the adoption of IT systems	0.29	0.46	0.00	1.00
Digital Complementary Assets	Number of IT Employees	Number of fulltime employees in the IT department	8.31	19.21	0.00	350.00
	Electronic Health Record	1 = hospital has an EHR system	0.75	0.43	0.00	1.00
	PACS	1 = hospital has a picture archiving and communication system	0.71	0.45	0.00	1.00
	Videoconference	1 = hospital has videoconferencing facilities	0.45	0.50	0.00	1.00
	HIE Functionalities	Categorical variable				
	HIE: no functionalities[a]	1 = no HIE functionalities	0.39	0.49	0.00	1.00
	HIE: Radiology Reports	1 = hospital can exchange radiology reports with other health care providers	0.47	0.50	0.00	1.00
	HIE: Medical Patient Data	1 = hospital can exchange medical patient data with other health care providers	0.38	0.48	0.00	1.00
	HIE: Laboratory Reports	1 = hospital can exchange laboratory reports with other health care providers	0.44	0.50	0.00	1.00
	HIE: Medication Lists	1 = hospital can exchange patient medication lists with other health care providers	0.24	0.43	0.00	1.00
Control Variables	Health Care Expenditures (pc)	Health care expenditures per capita at country level	2,409.08	970.57	752.74	4,610.45
	Number of Fulltime Employees	Total number of fulltime employees	1,291.46	2,099.74	1.00	32,000.00
	Adjusted Number of Employees	Number of employees divided through the average employee-to-bed-ratio (country level)	479.52	884.14	0.21	18,713.45
	Ownership	Categorical variable				
	Ownership: public[a]	1 = public hospital	0.70	0.46	0.00	1.00
	Ownership: private	1 = private hospital	0.30	0.46	0.00	1.00

	Group Affiliation	Categorical variable				
	Group Affiliation: independent hospital on one site[a]	1 = independent hospital on one site	0.41	0.49	0.00	1.00
	Group Affiliation: independent hospital on multiple sites	1 = independent hospital on multiple sites	0.31	0.46	0.00	1.00
	Group Affiliation: part of a group of different hospitals	1 = part of a group of different hospitals	0.20	0.40	0.00	1.00
	Group Affiliation: part of a group of care institutions	1 = part of a group of care institutions	0.04	0.21	0.00	1.00
	Group Affiliation: other	1 = other	0.03	0.17	0.00	1.00
	Teaching Status	Categorical variable				
	Teaching Status: non-university non-teaching hospital[a]	1 = non-university non-teaching hospital	0.52	0.50	0.00	1.00
	Teaching Status: university hospital	1 = university hospital	0.14	0.34	0.00	1.00
	Teaching Status: non-university teaching hospital	1 = non-university teaching hospital	0.34	0.47	0.00	1.00
Exclusion Restrictions	Adjusted wage medical transcriptionist	Average wage of medical transcriptionists/Average wage all occupations (country level)	0.73	0.12	0.47	1.06
	Adjusted wage medical records and health information technician	Average wage of medical records and health information technicians/Average wage all occupations (country level)	0.96	0.18	0.48	1.64

Notes: SD, standard deviation; Min, minimum; Max, maximum. [a]Reference category.

We included the following variables for **digital complementary assets** from the *European Hospital Survey* in our models: The first variable consists of the number of fulltime employees in the IT department (*Number of IT Employees*). This variable is metric. In addition, we incorporated a number of digital complementary technologies for each hospital: EHR, PACS, videoconferencing facilities, and various HIE functionalities. As a result, we are able to take the divergent nature of the individual telemedicine applications into account. We can draw a finer picture of the business model- and application-dependent effects of complementary technologies.

Control Variables

In order to take other contextual and organizational influences on the adoption of telemedicine applications into account, we included additional variables in our models: The adoption of telemedicine applications may depend on the stage of development of the health care system and the expenditures invested in health care. Therefore, we included health care expenditures per capita in our models (*Health Care Expenditures (pc)*).[2] We controlled for hospital size by including a metric variable recording the *Number of Fulltime Employees*. In addition, we controlled for the following hospital characteristics: *Ownership* (public, private), *System Affiliation* (independent hospital on one site, independent hospital on multiple sites, part of a group of different hospitals, part of a group of care institutions, other), and *Teaching Status* (non-university non-teaching hospital, university hospital, non-university teaching hospital). These organizational factors were found to influence HIT adoption [e.g., 1, 37, 44, 46, 105].[3]

Models

In order to test the adoption of telemedicine applications by incumbent hospitals, we used binary logistic regression models. We included 1,093 observations for Model 1 (Teleradiology) and Model 2 (Telemonitoring). Model 3 (Teleconsultation with Providers) comprises 1,065 and Model 4 (Teleconsultation with Patients) 1,072 observations. The logit model calculated the probability of adoption (1) compared with non-adoption (0) as relation $\frac{P(y=0)}{1-P(y=0)}$ using the regression function

$$Logit(y) = \beta_0 + \beta_i X_i \tag{1}$$

Results

Descriptive Results

Descriptive statistics are shown in Table 2. 1,014 out of 1,753 hospitals in the sample had adopted at least one of four telemedicine applications: teleradiology, telemonitoring, teleconsultation with other health care practitioners, or teleconsultation with patients (see Figure 2).

A total of 30 percent had adopted one telemedicine application, 16 percent two, 8 percent three, and 4 percent all four applications. Regarding the individual applications, 41 percent of the hospitals had adopted teleradiology, 14 percent had adopted telemonitoring, 31 percent teleconsultation with providers,[4] and 15 percent teleconsultation with

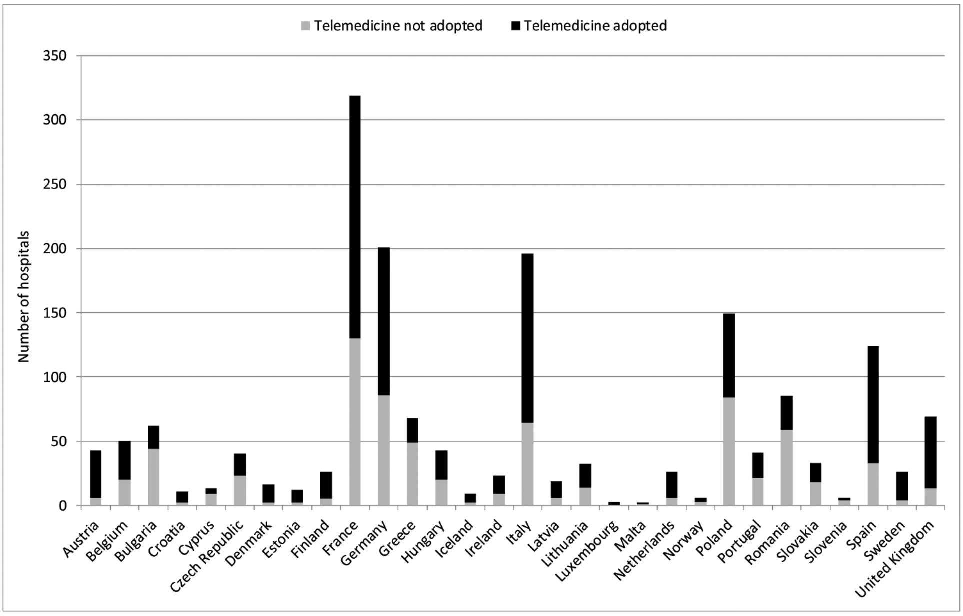

Figure 2. Adoption of telemedicine in European hospitals per country.

patients.[5] Obviously, provider-to-provider (B2B) applications are more diffused than provider-to-patient (B2C) applications. Overall, the adoption of telemedicine applications in European hospitals can be summarized as rather hesitant.

Comprehensive regulation and reimbursement norms for telemedicine are rare in Europe. Instead of specific regulation, most countries apply general data security and liability regulation. All European countries in the sample applied general data security legislation and general liability legislation[6] to telemedicine. Only Estonia, France, Germany, Portugal, and Sweden had enacted specific telemedicine regulation. Denmark, Finland, France, Germany, Norway, and Portugal had implemented specific telemedicine reimbursement norms.

With regard to the IT infrastructure, the prerequisites in the sample were overall good. A total of 76 percent of the hospitals had a computer system that was externally connected. Only three hospitals in the sample had no internet connection at all, while 54 were connected via narrowband and 1,541 via broadband. Furthermore, there were different types of computer systems implemented in the hospitals: 3 percent of the hospitals had no actual computer system but only isolated PCs, 62 percent an independent hospital-wide computer system, and 34 percent a computer system that was part of a network. Therefore, the basic infrastructure for the adoption of digital applications like telemedicine was available in most hospitals. HIT applications present important digital complementary assets for telemedicine applications. The picture regarding these applications is mixed: 71 percent of the hospitals had EHRs, 45 percent videoconferencing facilities, and 70 percent used a PACS. The implementation of HIE functionalities was distinctly lower: 45 percent of the hospitals were able to exchange radiology reports, 38 percent medical patient data, 42 percent laboratory reports, and 22 percent medication lists.

Table 3. Regressions: Incumbents' adoption of telemedicine applications.

	(1) Tele-radiology	(2) Tele-monitoring	(3) Tele-consultation Providers	(4) Tele-consultation Patients
Regulatory Framework				
Specific Telemedicine Regulation	-0.01	-0.05	-0.23	0.13
	(0.43)	(0.50)	(0.39)	(0.50)
Regulation for Security and Privacy of Data	0.26	-0.27	0.41	0.17
	(0.16)*	(0.21)	(0.18)**	(0.22)
Restrictive Telemedicine Regulation	0.52	-1.09	-0.24	-0.38
	(0.19)***	(0.37)***	(0.23)	(0.28)
Reimbursement Regulation for Telemedicine	-0.01	-0.52	0.63	0.45
	(0.42)	(0.49)	(0.39)	(0.50)
Financial Incentives tied to IT Systems	-0.04	0.47	0.18	0.01
	(0.16)	(0.20)**	(0.18)	(0.21)
Digital Complementary Assets				
Number of IT Employees	0.01	0.01	0.02	0.02
	(0.01)	(0.01)	(0.01)*	(0.01)*
Electronic Health Record	-0.04	0.44	0.70	-0.21
	(0.19)	(0.29)	(0.23)***	(0.26)
PACS	2.15	0.24	0.34	-0.04
	(0.21)***	(0.25)	(0.21)	(0.24)
Videoconference	0.63	0.58	1.37	0.58
	(0.16)***	(0.22)***	(0.18)***	(0.22)***
HIE Functionalities (reference group: no HIE Functionality)				
HIE: Radiology Reports	1.19	0.49	0.68	0.57
	(0.27)***	(0.39)	(0.33)**	(0.43)
HIE: Medical Patient Data	0.32	0.25	1.07	1.35
	(0.32)	(0.40)	(0.34)***	(0.38)***
HIE: Laboratory Reports	0.83	0.35	1.01	0.86
	(0.20)***	(0.27)	(0.22)***	(0.29)***
HIE: Medication Lists	0.65	0.60	1.78	1.64
	(0.21)***	(0.28)**	(0.23)***	(0.29)***
Control Variables				
Health Care Expenditures (pc)	0.00	0.00	-0.00	-0.00
	(0.00)	(0.00)**	(0.00)	(0.00)
Number of Fulltime Employees	-0.00	0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Ownership (reference group: public)				
private	-0.15	-0.24	-0.25	0.13
	(0.18)	(0.24)	(0.20)	(0.22)
Group Affiliation (reference group: independent hospital on one site)				
independent hospital on multiple sites	0.37	0.42	-0.23	-0.16
	(0.18)**	(0.23)*	(0.21)	(0.23)
part of a group of different hospitals	0.35	0.14	-0.23	-0.01
	(0.21)	(0.28)	(0.23)	(0.27)
part of a group of care institutions	0.34	0.68	-0.29	0.18
	(0.34)	(0.44)	(0.39)	(0.42)
other	0.12	-0.54	0.19	0.27
	(0.42)	(0.76)	(0.49)	(0.55)
Teaching Status (reference group: non-university non-teaching hospital)				
university hospital	0.06	0.28	0.46	0.52
	(0.23)	(0.32)	(0.29)	(0.32)
non-university teaching hospital	-0.24	0.42	0.31	0.55
	(0.17)	(0.22)*	(0.18)*	(0.22)**
Constant	-3.27	-4.08	-3.59	-2.88
	(0.30)***	(0.43)***	(0.36)***	(0.38)***
Wald Test Statistic	246.76	98.65	245.32	115.04
p Value	0.00	0.00	0.00	0.00
Observations	1,093	1,093	1,065	1,072

*p < 0.1. **p < 0.05. ***p < 0.01; standard errors in parentheses.

Results of Logistic Regression Analysis

To test our hypotheses, we estimated four separate models using the STATA software. Table 3 shows the results of our regression analyses. Model 1 tested the effects on the likelihood of teleradiology adoption and Model 2 of telemonitoring adoption. Models 3 and 4 tested respectively the effects on the probability of adoption of teleconsulting with providers and patients.

Digital Complementary Assets

The number of IT employees had a significant positive effect on the likelihood of adoption of teleconsultation with providers ($b = 0.02$, $p < 0.1$) and with patients ($b = 0.02$, $p < 0.1$) (Models 3 and 4). The existence of an EHR system had a significant positive effect on teleconsultation with providers ($b = 0.70$, $p < 0.01$) (Model 3). This finding shows the high relevance of the availability of comprehensive patient data for teleconsultation between health care professionals. PACS only had a significant positive effect on teleradiology ($b = 2.15$, $p < 0.01$) (Model 1). This effect is not surprising, since this digital complementary technology for archiving and exchanging radiological images is highly relevant for teleradiology. In contrast, the existence of videoconferencing facilities had a highly significant effect in all four models (Teleradiology: $b = 0.63$, $p < 0.01$; Telemonitoring: $b = 0.58$, $p < 0.01$; Teleconsultation with Providers: $b = 1.37$, $p < 0.01$; Teleconsultation with Patients: $b = 0.58$, $p < 0.01$). Obviously, the ability to talk to each other via videoconference is an important substitute for personal contact when actors are spatially separated from each other. The HIE functionalities also had application-specific effects: The ability to exchange radiology reports significantly increased the likelihood of the adoption of teleradiology ($b = 1.19$, $p < 0.01$) (Model 1) and teleconsultation with providers ($b = 0.68$, $p < 0.05$) (Model 3). Since the interpretation of these reports requires expert knowledge, it is consequential that this functionality is relevant for provider-to-provider applications. The ability to exchange medical patient data had a significant positive effect on teleconsultation with providers ($b = 1.07$, $p < 0.01$) and with patients ($b = 1.35$, $p < 0.01$) (Models 3 and 4). This finding is not really surprising in consultation contexts, where comprehensive medical data is crucial for profound discussions of the medical condition of a patient. HIE functionalities for laboratory results had a significant positive effect in the Models 1, 3, and 4 (Teleradiology: $b = 0.83$, $p < 0.01$; Teleconsultation with Providers: $b = 1.01$, $p < 0.01$; Teleconsultation with Patients: $b = 0.86$, $p < 0.01$). The ability to exchange laboratory results is important for provider-to-provider applications, where the health care professionals need comprehensive information about a patient in order to make decisions when the patient is not personally present. In addition, it is important in for teleconsultation with patient, where laboratory results are often discussed. Finally, the ability to exchange medication lists significantly increased the likelihood of adoption in all four models (Teleradiology: $b = 0.65$, $p < 0.01$; Telemonitoring: $b = 0.60$, $p < 0.05$; Teleconsultation with Providers: $b = 1.78$, $p < 0.01$; Teleconsultation with Patients: $b = 1.64$, $p < 0.01$). Since knowledge about the medication of a patient is highly relevant for many treatment decisions, this strong effect is not surprising. In sum, Hypothesis 1 is at least partially supported in all four models. However, the support is somewhat stronger for provider-to-provider (B2B) applications, where the availability of as comprehensive data as possible is very important.

Regulatory Framework

Surprisingly, specific telemedicine regulation does not have a significant impact in any of the four models. Regulation for security and privacy of data has a highly significant positive impact on the adoption probability of teleradiology ($b = 0.26$, $p < 0.1$) (Model 1) and teleconsultation with providers ($b = 0.41$, $p < 0.05$) (Model 3). The exchange of confidential information between providers may be encouraged by this protective regulation [88]. Yet, the regulation for security and privacy does not exhibit any significant effect in the Models 2 and 4. Restrictive telemedicine regulation, on the other hand, exhibits a significant positive effect on the adoption probability of teleradiology in Model 1 ($b = 0.52$, $p < 0.01$). In contrast, restrictive telemedicine regulation has a significant negative impact on the adoption probability of telemonitoring ($b = -1.09$, $p < 0.01$) (Model 2). Reimbursement regulation for telemedicine did not exhibit a significant effect in any of the models. In contrast, financial incentives tied to IT systems show a significant positive influence on the likelihood of adoption of telemonitoring in Model 2 ($b = 0.47$, $p < 0.05$). As telemonitoring will diminish office visits, the positive impact of financial incentives seems warranted. Compensation for lost fees may increase incumbents' motivation and thus the likelihood of adoption. Overall, we observed that the impact of the regulatory framework on the adoption on telemedicine applications is rather low as well as conflicting. Therefore, Hypothesis 2a is not supported in the Models 2 (telemonitoring) and 4 (teleconsultation with patients) for provider-to-patient (B2C) applications. Nevertheless, it is partially supported for the provider-to-provider (B2B) applications teleradiology and teleconsultation with providers in Models 1 and 3. Hypothesis 2b, on the other hand, is supported for teleradiology (Model 1), and telemonitoring (Model 2), but is not supported for teleconsultation with providers and patients (Models 3 and 4). Hypothesis 2c is not supported for teleradiology (Model 1) and teleconsultation with providers and patients (Models 3 and 4), while it is at least partially supported for telemonitoring (Model 2). These findings strongly indicate that the impact of the regulatory framework may differ among applications, business models, and contexts. Overall, our findings clearly suggest that digital complementary assets have a more robust influence on the adoption of telemedicine applications than the regulatory framework.

Control Variables

Health care expenditures per capita only exhibited a significant impact in Model 2, yet without magnitude ($b = 0.00$, $p < 0.05$). Neither the size of the hospital nor the ownership structure had a significant effect in any of the models. With regard to group affiliation, independent hospitals on multiple sites significantly increased the likelihood of teleradiology ($b = 0.37$, $p < 0.05$) and telemonitoring ($b = 0.42$, $p < 0.1$) adoption compared to independent hospitals on one site in Models 1 and 2. None of the other kinds of group affiliations had any significant effect in any of the models. Finally, we controlled for the effect of university and teaching hospitals in our models. Non-university teaching hospitals exhibited a significant positive impact compared to non-university non-teaching hospitals in Models 2 to 4 (Telemonitoring: $b = 0.42$, $p < 0.1$; Teleconsultation with Providers: $b = 0.31$, $p < 0.1$; Teleconsultation with Patients: $b = 0.55$, $p < 0.05$). Other than that, we observed no significant effects of this variable.

Additional Analyses and Robustness Checks

In order to check the robustness of our findings, we conducted additional tests. First, we adjusted the measurement for the size of hospitals for country differences by dividing the number of employees through the average employee-to-bed-ratio at a country level. The results are consistent with the previous findings, as shown in the Online Supplemental Appendix 1.

Second, we have considered a two-stage binary sample selection model. EHR adoption could present a possible bias in the sample since EHRs are an important infrastructure for some digital applications. When dependent variables are observed for a nonrandom portion of the sample that is dependent on another, potentially observable variable, sample selection bias occurs. The use of a two-stage model that includes sample selection correction can account for this bias [35]. Hence, we decided to use EHR adoption as a dependent variable in the first-stage model to control for potential sample selection bias. The first-stage model (selection equation) requires at least one exclusion restriction that is not present in the second-stage models [108]. Analogous to Baird et al. [5], we used the adjusted wages of *medical transcriptionists* and *medical records and health information technicians* at a country level as exclusion restrictions for the first-stage model. Hospitals mainly adopt EHRs to increase productivity and efficiency. This is achieved by the replacement of paper records and the improvement of inefficient processes through EHRs. In contrast, telemedicine applications are primarily adopted to improve the quality of and access to health care. Therefore, EHR adoption decisions are moderated by operational cost, while cost considerations are less associated with telemedicine adoption. Thus, the wages of employees that can be reduced or replaced by EHR adoption are likely to be highly correlated with EHR adoption but not with telemedicine adoption. As a result, the wages of *medical transcriptionists* and *medical records and health information technicians* are qualified to be included as exclusion restrictions in the first-stage model. We obtained data on the wages of *medical transcriptionists* and *medical records and health information technicians* at a country level and divided these wages through the average wage of all occupations (also at country level) to adjust for endogenous effects (e.g., cost of living) and to isolate the wage effect. In the first-stage model, we excluded all regulation variables that exclusively apply to telemedicine, because they are not relevant for EHRs. Online Supplemental Appendix 2 reports results that are consistent with our previous findings.

In addition, the existence of EHRs was not the sample selection criterion in the survey. Hospitals were selected based on the fact that they were an acute care hospital. 71 percent of the hospitals in the sample had adopted an EHR system and 24 percent had no EHR in place (missing: 5 percent). The correlation between EHR and the telemedicine applications is low (between 0.09 and 0.20), and there are hospitals in the sample that adopted telemedicine applications without having an EHR system (teleradiology: 121 hospitals, telemonitoring: 31, teleconsultation with providers: 62, teleconsultation with patients: 39). Thus, the sample is not likely to be biased because there is variation in EHR adoption. Furthermore, EHR adoption is not a mandatory prerequisite for the adoption of the digital complementary technologies and telemedicine applications.

Discussion

Our findings suggest that the likelihood of the adoption of telemedicine applications is first and foremost influenced by the existence of digital complementary technologies, whereas the role of the regulatory framework is more ambiguous.

Regarding digital complementary technologies, we found that the effects of the individual complementary technologies are application- and business model-dependent, which emphasizes the relevance of breaking our dependent variables into different B2B and B2C applications. Moreover, the limited impact of the number of IT employees, which does not represent an innovation-specific complementary asset in the first place, affirms the importance of specialized rather than generic assets [91, 95]. Yet, our findings indicate that the number of IT employees may be of higher importance for consultation applications, which require quite comprehensive data and thus a higher degree of system integration. Taken together, these findings illustrate that infrastructure and technological competences acquired due to the employment of digital complementary assets such as EHR, PACS, videoconferencing facilities, or HIE functionalities will increase the likelihood of the adoption of digital innovations such as telemedicine, and confirm the importance of complementary assets in the face of discontinuous innovations. Thus, we contribute to the IS literature on the significance of organizational resources such as digital complementary assets for the adoption of IT innovations [e.g., 43, 71, 86].

With regard to the regulatory framework, the oppositional impact of restrictive regulation on teleradiology and telemonitoring enables interesting insights: restrictive regulation consists primarily of the need for treatment in person. This regulation is relevant for telemonitoring, where patients are supervised from a distance. Teleradiology, in contrast, is a provider-to-provider application and therefore not affected by this regulation. Our findings indicate that restrictive regulation may cause a shift away from the adoption of provider-to-patients to provider-to-provider applications, which is likely to have caused the positive impact on teleradiology. Hence, regulation can exhibit effects that are business model specific (e.g., with respect to the customer segment) [e.g., 14]. In addition, our findings suggest that the degree of discontinuity [31, 40] of the digital innovation may be a potential parameter: teleradiology and telemonitoring, which have a stronger discontinuous character, are significantly affected by restrictive regulation. In contrast, the two teleconsultation applications with weaker discontinuous aspects show no significant effect.

Moreover, specific telemedicine regulation exhibits no significant effect on the adoption likelihood in any of the models, whereas the influence of regulation for security and privacy of data varies across applications. The effect is significantly positive for provider-to -provider business models, where comprehensive sensitive data is exchanged, but not for provider-to-patient business models. This finding may provide important implications not only for health care, but also for other B2B contexts where sensitive data are transmitted. On the other hand, it indicates that data security concerns may have less prominence in B2C contexts. Reimbursement regulations exhibit no significant and financial incentives only a limited impact in our sample.

In part, these findings may be caused by the fact that during institutional transitions such as the digital transformation of the health care sector, organizations cannot fully assess the regulatory context of a discontinuity. As a result, incumbent organizations may be reluctant to adopt discontinuous innovations, at least until the new regulatory context becomes better defined [65]. Market-based strategies that focus on competitive resources and capabilities [6], on the other hand, present a primary strategic choice [e.g., 64, 68]. Therefore, organizations are likely to concentrate on resources such as complementary assets in times of institutional transition [30]. In addition, the regulatory framework can either promote or inhibit discontinuous change by requiring organizational accountability and by influencing resource flows [e.g., 21, 41]. Therefore, regulatory elements can yield contradictory effects on discontinuous change [19]. Thus, our findings provide further support for the importance of studying institutional and, in particular, regulatory determinants in IS research [e.g., 39].

In sum, hospitals endowed with digital complementary assets seem to have an incentive to adopt innovations that can leverage these digital complementary assets, even if these innovations may face disadvantageous economic conditions (e.g., lack of reimbursement regulation). Digital complementary assets may amplify returns on investment in the innovation, thereby increasing the incumbents' economic incentive to adopt the innovation [114]. As a result, digital complementary assets represent key resources [e.g., 45, 67] in business models for discontinuous digital innovations in this context.

Theoretical Contributions

By studying the role of digital complementary assets and the regulatory environment in the adoption of discontinuous digital innovations, our research makes the following three contributions.

First, our findings contribute to IS research on digital transformation by studying adoption determinants of discontinuous digital innovations. Incumbents, in particular, are bound by economic and cognitive path dependences of legacy systems [89, 104]. Thus, our study provides valuable insights into incumbent responses to digital transformation, responding thereby to the calls for research on digital transformation at multiple levels of analysis in IS literature [39, 60, 104]. While prior IS research has already provided important insights into drivers of IT innovation adoption such as individual's behavioral intentions toward adopting IT innovations (i.e., technology acceptance literature) [e.g., 10, 11, 20, 69, 102], organizational drivers [e.g., 43, 86], and institutional pressures and legitimacy [e.g., 34, 77, 93, 110], we focus specifically on the context of discontinuous digital innovations.

This is relevant because in contrast to questions of substitution of paper-based documentation with a digital system such as EHRs [e.g., 34, 53] or efficiency improvements through IT-based processes [e.g., 33, 34], discontinuous digital innovations pose additional challenges to incumbent organizations that go beyond adaptions of organizational processes, requiring a restructuring of existing processes and sometimes even changes to the prevalent business model. Thus, this research topic is especially important because most incumbents are unlikely to employ discontinuous business models. Rather, they prefer to use digital technologies to extend or revise existing processes in an evolutionary manner [28, 45, 106]. Moreover, we account for different business models (B2B vs. B2C), which enables novel insights into new collaboration and coordination possibilities through digital technologies [104]. As a result, our research yields a fine-grained account of incumbent responses to digital transformation.

Second, we advance research on incumbents' response to discontinuous digital innovations by providing further evidence of the role of digital complementary assets as a means to counteract incumbents' inertia and by quantifying the relative importance of regulatory and organizational factors. Thus, we contribute to the growing body of recent IS literature on innovation research [27, 112]. We build on the resource-based view of complementary assets and add the role of the regulatory framework to the study of the drivers of incumbent adoption of discontinuous digital innovations. Our findings emphasize the relevance of digital complementary assets over the regulatory framework. In particular, we showed that incumbent hospitals that possess technological knowhow will perceive the characteristics of the innovation differently, thus altering their innovation adoption process [70, 91]. Hospitals that do not possess these competencies will face more severe challenges in adopting these innovations. Thus, these incumbents will be less likely to adopt discontinuous digital innovations such as telemedicine even when they are incentivized to do so by the regulatory framework. Consequently, regulatory incentives do not seem to be able to compensate for missing infrastructure and technological competences, at least in the short-term.

Moreover, our findings on the ambiguous impact of the regulatory framework provide evidence that discontinuous digital innovations may gain a foothold in areas where they can circumvent restrictive regulation [14]. This supports the notion that regulatory free spaces or time lags in regulatory adaption to digital innovations may provide a "grey" space for experimenting with new business models [39]. Furthermore, extant literature argues that the regulatory framework alone will not develop into a profitable strategy for technology and innovations. Control and ownership of complementary assets by organizations is expected to be equally imperative [83]. By acquiring technological capabilities, organizations are not only able to make better strategic choices within the institutional context [13], but they are also able to acquire bargaining power in the negotiation with resource owners and institutions [83].

Hence, our paper contributes to recent calls to holistically study the attributes of the environment, the organizations, and the innovations and thus integrate resource- and institution-based considerations [e.g., 56, 66] to better understand which regulatory or organizational factors facilitate incumbent adoption of discontinuous innovations in a strongly regulated context [89]. Only recent studies have started to adopt an integrated perspective of the resource- and institution-based view in different industries [3, 30, 56]. To our knowledge, there are so far no empirical studies investigating this topic in the context of discontinuous digital innovations in a service-dominated sector such as health care.

Third, our findings contribute important insights on the adoption of digital innovations in health care. Current HIT adoption literature mainly focuses on the importance of institutional factors (e.g., laws and regulations), environmental factors (e.g., location, competition) as well as organizational characteristics (e.g., size, system affiliation, and tax status) [e.g., 44]. Yet, complementary assets remain underexplored. By highlighting the importance of digital complementary assets for telemedicine adoption, our paper makes a relevant contribution given that digital innovations were not yet able to fulfill their promise of improved health care delivery and cost savings. Extant research has mostly focused on single-country analyses [30]. By including a variety of European countries, we not only recognize the demand for cross-country studies examining contextual factors

[17], but also enhance the generalizability of our findings in a highly relevant sector. In addition, we examine a service industry where discontinuous innovations are enabled by technologies that offer opportunities to provide new and innovative services. In this context, discontinuous innovations denote significant changes in how value is co-created. As a result, we provide a service-dominant perspective that departs from the predominant research in product-dominated industries [e.g., 54, 101].

Practical Implications

Our findings further enable important insights for policy makers and managers. For policy makers, we argue that public policy aimed at promoting digital innovation in health care should also focus on digital complementary assets and the underlying infrastructure [91]. Policy makers can facilitate the creation of digital complementary assets and infrastructure by providing education and training, defining crucial complementary assets, and incentivizing their acquisition. Furthermore, our findings support the argument that matching policies with the characteristics of the innovation may be crucial in accelerating technology development [e.g., 97]. Yet, although regulations are an important institutional intervention for digital innovations, they may also produce counterproductive consequences [48].

On the one hand, our findings show that regulation can exert application- and business model-specific effects. On the other hand, regulators have only limited knowledge about the technological, organizational, and business model-related complexities of the intricate digital innovations in this context. As a result, regulators should weigh carefully whether they intend to design regulation that is application-independent and generally applicable or regulation that is more application-specific. This decision can also affect the evolution of digital innovations since the scope of regulation may enable or restrict innovative concepts. Therefore, our research may help policy makers to make better-informed decisions and avoid unintended consequences such as restrictive regulation (i.e., the need for treatment in person), which has a significant negative impact on the adoption probability of telemonitoring. Regulatory sandboxes [e.g., 98] could be helpful to test the distinct impact of different types of regulations on digital innovation and to derive conclusions on how supportive regulation needs to be designed. Thus, regulatory sandboxes might represent an adequate means to reduce the uncertainty associated with future discontinuous digital innovations.

Our findings further provide an important recommendation for managers of incumbent hospitals and other organizations faced with discontinuous digital innovation: Traditional service providers such as hospitals should increase investments in digital technological competences if they want to participate in innovations such as telemedicine. In order to facilitate adoption of these innovations, managers may stimulate the accumulation of specialized digital complementary assets for these innovations. By doing so, they will provide their organization with an adequate IT infrastructure for the adoption. Furthermore, they are investing in the development of dynamic capabilities and thus of absorptive capacity, which will result in a higher aspiration level and, in turn, will increase the likelihood of pursuit of future innovative opportunities [15, 43, 106, 115]. Thus, they not only comply with pressures from policy makers, but also enable their organizations to deliver state-of-the-art services and to remain competitive. IT managers will find valuable support in these findings for their reasoning for higher investment in the hospital's IT budget.

Limitations and Future Research

In spite of the contributions of our research, this study's limitations provide ample opportunities for future research. First, our results show that the value of digital complementary assets and regulations varies across telemedicine applications, indicating that context may play a dominant role in the adoption of innovations. Therefore, further context-, business model-, and application-specific research is necessary in order to fully understand the complex interactions of influencing factors. Qualitative in-depth studies may provide important fine-grained insights. Second, we do not observe how changes in the regulatory context over time may interact with digital complementary assets and how the impact of regulation and digital complementary assets may change as a consequence. Thus, a dynamic perspective of the impact of regulation and digital complementary assets on discontinuous digital innovations provides an interesting area of research for the future.

Conclusions

Our study investigates the role of digital complementary assets and the regulatory environment in the adoption of discontinuous digital innovations in health care based on empirical insights from 1,753 acute care hospitals across 30 European countries. Our findings suggest that digital complementary assets such as EHRs, PACS, videoconferences, or HIE functionalities have a stronger effect on the adoption of telemedicine applications in incumbent hospitals than the regulatory framework, which consists of (i) a general regulatory framework for telemedicine, (ii) regulation that imposes restrictions on the treatment of patients by telemedicine, and (iii) reimbursement regulation for telemedicine and financial incentives. The effects of digital complementary assets on the adoption of telemedicine are somewhat stronger for B2B applications (i.e., teleradiology and teleconsultation with providers) when compared to B2C (i.e., telemonitoring and teleconsultation with patients). Our quantification of the relative effect of regulatory and organizational factors such as digital complementary assets enables in-depth insights into how discontinuous digital innovations are adopted within incumbent organizations. Thus, our research shows how digital complementary assets can serve as a means to overcome incumbents' inertia, and advances the current understanding of incumbent responses to digital transformation. Moreover, our provision of large-scale empirical evidence across 30 European countries in the health care context addresses the lack of understanding of which contextual and organizational factors affect the diffusion of digital innovations such as telemedicine. Hence, our findings enable valuable insights into how the hesitant diffusion of digital innovations can be accelerated by promoting the establishment of digital complementary assets at the firm-level. Our study has important implications for policy makers and managers of incumbent hospitals that may guide them in exploiting the potential of digital transformation for improving health care provision and realizing cost savings.

Notes

1. The EU27 countries are Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.
2. Regulatory and economic measures as well as health care expenditures can also depend on the level of economic development of countries. This fact can be controlled for by including GDP per capita for each country in the models. Yet, due to high correlation with health care expenditures, we excluded GDP from the analysis. However, we also included GPD per capita instead of health care expenditures in all the models and tested these models *ceteris paribus*, and the effects proved to be robust.
3. After the exclusion of GDP, the collinearity diagnostics of all variables resulted in VIF values ≤ 9.37. VIF values of less than 10 are indicative of inconsequential collinearity. Furthermore, STATA automatically detects and removes variables causing perfect collinearity.
4. 5 percent missing
5. 4 percent missing
6. Except for Greece, where a legal gap in relation to medical liability for advice provided in distance was in place.

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