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Managing the Exploration-Exploitation Paradox in Healthcare: Three Complementary Paths to Leverage on the Digital Transformation

STRUCTURED ABSTRACT

Purpose. To understand how digital technologies can help healthcare organisations to improve the exploration-exploitation paradox over time. We explore inputs, processes, and outcomes of implementing digital transformation programs and advance four testable propositions.

Design/methodology/approach. We conducted multiple case studies with embedded units of analysis: 1) digital transformation processes; 2) hospitals; 3) regional healthcare systems. Primary sources come from 107 semi-structured interviews with key informants within 14 Italian hospitals between 2009 through 2011.

Findings. Three complementary paths emerge as fundamental to balance exploratory and exploitatory efforts in healthcare: (i) assets digitalisation within hospitals; (ii) digitally-based process integration; (iii) disruptive decision-making through analytics. Intra- and inter-path characteristics are discussed to show how digital transformation can both move hospital within the exploration-exploitation space.

Research limitations/implications. By its very nature, this study is exploratory. Notwithstanding the number of cases and interviews, its generalisability is limited.

Practical implications. Digital transformation programs are fundamental to resolve the tensions raised by the exploration-exploitation paradox. Their implementation leads to better performance (cost reductions, quality improvements). A framework is provided for practitioners to make better decisions.

Originality/value. This study sheds new light on how digital technologies are actually adopted and adapted in healthcare contexts. It does it by entailing a longitudinal perspective.

Keywords: Exploration; Exploitation; Ambidexterity; Efficiency Frontier; Digital technologies; Healthcare
JEL: I10, L31, O33, O30

INTRODUCTION

Healthcare organisations are currently trying to reconfigure and innovate their processes in order to achieve and maintain a continuous balance between quality improvement and cost rationalisation (Porter and Lee, 2013; McCullogh and Snir, 2010; Borzekowski, 2009; Djellal and Gallouj, 2007). Underlying this twofold aim, tensions emerge being produced by exploratory and exploitatory behaviours (Lavie *et al.*, 2010), acting as opposing attractors whose effective balance can only be reached by deploying concrete and persistent efforts. In this vein, latest ambidexterity research (Birkinshaw and Gupta, 2013) suggests exploring the processes through which organisations cope with these tensions over time, reconfiguring their activities within an exploration-exploitation space limited by an efficiency frontier, or pushing it out to achieve higher performance.

The digital transformation characterising the healthcare sector nowadays (Lin *et al.*, 2014; Kaushal and Blumenthal, 2014; Andreassen *et al.*, 2015; McAlearney *et al.*, 2015; Arvanitis and Loukis, 2016) offers important research opportunities from this viewpoint. Furthermore, it is also at the centre of the debate among policymakers and practitioners because of its potential impact in term of both cost reduction and quality improvement (OECD, 2016). The World Economic Forum (2016) shows that, although digital healthcare attracted more than $14 billion in funding and investment over the past six years, concrete actions still have to be implemented in order to structurally transform the industry. Indeed, if properly implemented, digital technologies can improve patient empowerment, quality of life, enable the communication among healthcare professionals and patients, and reduce both errors and length of hospitalisation (European Commission, 2012; European Commission, 2014). An effective introduction of digital technologies provides occasions to: (i) re-engineer healthcare processes (Laing, 2002); (ii) balance exploratory and exploitatory efforts (Gastaldi and Corso, 2013); (iii) improve the way healthcare services are offered—both in terms of cost and quality (Agarwal *et al.*, 2010; Borzekowski, 2009). However, literature has produced little evidence on how digital technologies can actually achieve these results.

By analysing 14 Italian hospitals, and considering their peculiar role in the healthcare innovation process (Thune and Mina, 2016), we want to shed new light on the following research question: How do digital technologies impact on healthcare processes, regarding cost reduction and quality improvement, balancing ambidextrous tensions?

In the theoretical background, we discuss the exploration-exploitation paradox and introduce an Input-Process-Output framework. Then, we provide methodological details and derive important findings from the cases analysed. The following section characterises the three paths leading healthcare institutions towards a resolution of the paradox via the implementation of digital transformations. Contributions for both theory and practice are discussed.

THEORETICAL BACKGROUND

Exploration and exploitation represent overarching demands, spurring nested tensions throughout the organisation (Andriopoulos and Lewis, 2009). Paradox thinking assumes these tensions can be beneficial if adequately harnessed (Andriopoulos and Lewis, 2009). This is because the juxtaposition of coexisting opposites intensifies experiences of tension, challenging actors' cognitive limits, demanding creative sense making, seeking more sustainable management strategies (Benner and Tushman, 2015).

From this viewpoint, Birkinshaw and Gupta (2013) propose the concept of 'Efficiency Frontier' (EF). Accordingly, organisations choose first, where to position themselves in the exploration-exploitation space delimited by the EF; second, whether organising their processes in such a way that the EF will be reached; third, look for peculiar configurations allowing them to progressively push it out. Moving through the EF entails going through a series of paths that may be more or less complex. How to move in this space is the core focus of recent research (O'Reilly and Tushman, 2013). Burgelman and Grove (2007) suggest that to accommodate these conflicting alignments, organisations need to shift their structures sequentially over time, to align them with firm's strategy. This school of thought looks at exploration and exploitation as two ends of a single continuum, placing inherently conflicting resource and organisational demands on the firm. This approach may allow organisations to innovate beyond—or at least within—the EF.

Other researchers have begun characterising exploration and exploitation as independent activities, orthogonal to each other: firms can choose to engage in high levels of both at the same time (Simsek *et al.*, 2009). Two ways of carrying them out together have been identified: *structural* and *contextual* (O'Reilly and Tushman, 2013). The former occurs through the simultaneous pursuit of both exploitation and exploration by using separate subunits. The latter suggests leveraging on the individual behavioural capacity to "simultaneously demonstrate alignment and adaptability across an entire business unit" (Gibson and Birkinshaw, 2004); this approach may allow organisations to innovate by pushing the EF out (Messeni Petruzzelli, 2014).

Raisch *et al.* (2009) found a combination of different solutions may be more practical. An effective way to find a solution to these emerging paradoxical tensions in healthcare institutions is through digital transformations (Gregory *et al.*, 2015). They are making increasingly possible deploying new ways of working that were not previously possible. Digital technologies leverage on knowledge assets (Leidner *et al.,* 2010), nurture innovation (Drnevich and Croson, 2013), reconcile the capability to exploit the current knowledge base opening to more exploratory ones (Laing, 2002). An effective digital transformation contributes in shifting the EF up and to the right—allowing not only a higher level of ambidexterity to be reached (Im and Rai, 2014), but also to improve the way healthcare services are offered—both in terms of cost and quality (Agarwal *et al.*, 2010). Improvements in healthcare quality include lower mortality rates, improved vaccination rates, increased use of recommended procedures, and patient safety. Lower costs, higher revenues, and higher productivity can contribute to bending the *cost* curve of healthcare processes.

In dealing with ambidextrous approaches, we adopt an *Input–Process–Output* (IPO) framework (Simsek, 2009). Each IPO configuration will represent a specific position concerning the EF. The framework helps to answer our research question because it considers the delivered ambidextrous activities (i.e. Processes) and the resulting *consequences* (i.e. Outputs). Furthermore, for every process, it takes into account the *antecedents* (i.e. Inputs) of balanced and ambidextrous processes at different levels of analysis (Figure 1). According to literature, antecedents are a complex function of:

- *Characteristics of the enabling digital solutions*: mainly in terms of resources, capabilities, and investments required (e.g., Im and Rai, 2014; Lin *et al.*, 2014);
- *Strategic time frame*: considered in terms of short, medium, long term perspectives (Piao, 2010).

Processes should be meant as *components* of balanced and ambidextrous use of exploration and exploitation. Such components can be thought of as a complex function of:

- *Approach to balance exploration and exploitation activities*: focusing on exploitation-driven, exploration-driven, co-evolving approaches (O'Reilly and Tushman, 2013);
- *Distance from the efficiency frontier*: depending on whether one pursues exploration and exploitation inside, at, or beyond it (Birkinshaw and Gupta, 2013).

Finally, the output should be thought of as *consequences* of balanced and ambidextrous use of exploration and exploitation. Such consequences can be described as a complex function of:

- *Degree of innovativeness*: incremental, radical, and disruptive outcomes (e.g., Garcia and Calantone, 2002);
- *Performance*: mostly in terms of cost rationalisation and quality improvement (Smith and Lewis, 2011; Borzekowski, 2009).

– Figure 1. Input–Process–Output framework –

METHODS

We implemented an interpretative, inductive perspective, based on multiple case studies (Eisenhardt, 1989; Yin, 2003). We worked on grounding the main constructs into the healthcare context. On the basis of March's (1991) seminal work, we defined:

- *Exploratory activities*: activities that explore innovative and better alternatives to deliver administrative and clinical services in order to change existing routines;
- *Exploitatory activities*: activities that refine and extend the existing competences, simplifying the use of existing routines in both the administrative and clinical domains.

Both definitions are based not only on literature analysis but also on the suggestions of a group of more than 60 practitioners who contributed in defining a taxonomy of the digital solutions (Table 1) over which a hospital can base its digital transformation.

– Table 1. Digital solutions adopted by hospitals –

The first unit of analysis focuses on the unfolding process of digital transformation: it refers to the set of activities and users involved in the adoption, usage and improvement of one of the digital solutions listed in Table 1. To escape abstraction and given the different degrees of innovativeness of the various solutions implemented, we adopted the hospital as a second unit of analysis and the regional healthcare system around the hospital as a third unit of analysis. Furthermore, embedded units of analysis allow us to go beyond the boundaries of the single process regardless the inputs (e.g., external pressures for the integration with EHR) or the outputs (e.g., the implementation of a telemedicine service could bring to privacy concerns due to the presence of an external actor) (Yin, 2003).

We focused on the digital transformations accomplished within 14 Italian hospitals. The selection of the hospitals was related to the importance they gave to the strategic implementation of digital transformations and the fact that they were all in the same geographical context, which provided the same boundary conditions. The primary data source was 107 semi-structured interviews over three years (Jan. 2009 - Dec. 2011) with Chief Information Officers (CIOs), at least one of the other C-levels (Chief Executive Officers (CEOs), Chief Financial Officers (CFOs), Chief Medical Officers (CMOs)) and—through a snowball technique (Patton, 2002)—other knowledgeable informants involved in the digital transformations of the hospitals (e.g., nurses, physicians). Within each hospital, we continued recruiting informants until additional interviews failed to dispute existing categories or relationships (Table 2).

– Table 2. Hospitals involved in the case studies and interviews accomplished –

Each interview lasted at least 2 hours and was designed along a common protocol that evolved during the research. Data were collected in three waves: first, we analysed the different solutions present inside the hospitals, and those that would be developed in the near future (starting before the end of 2012); in the second and third waves, we focused on the digital transformations.

– Table 3. Digital solutions characterising the digital transformation that has been studied –

RESULTS

Path A: Assets Digitisation

Step 1: Efficiency Stimulus

In all cases, the initial objectives of the digital transformation were related to exploit more effectively the resources of the hospital, and achieve efficiency—mainly regarding time savings, cost reduction, or managerial simplification. From this viewpoint, the CEO of H_2 stated that: "*Basically we dematerialise to cut costs*". For other representative quotes as well as the characterisation of the various cases on the IPO framework, see the attached e-companion.

A common element emerging from all cases is that it is better focusing on the digitisation of one hospital unit at a time. This allows addressing two objectives: (i) achieving tangible results in short time lags to be shown to the strategic board; (ii) reducing the complexity to be faced in the development of pervasive digital transformations. As the CIO of H_5 commented:

> "I*t is better focusing on a department at a time. Why? Because it is possible to avoid the over-complications associated with the development of pervasive solutions—at least in the initial digitalisation stages and/or in the case of low budgets available*".

Digitisation in the clinical domain is preferred to the one in the administrative domain, as expressed by the chief radiologist at H_2:

> "*First you have to focus on clinical assets, and then on administrative ones. The reasons are mainly related to the higher value associated with clinical digitalisation*".

In fact: (i) most of the assets that can be digitised within a hospital are of a clinical nature; (ii) clinical digitisation provides more opportunities both to explore and exploit; (iii) digitisation in the clinical area produces stronger positive impacts on hospital performance—both those directly perceived by physicians (as suggested by the interviews accomplished within H_2) and by patients (H_7), as well as those not directly perceived by most of the stakeholders (H_5). Informants suggested radiology and laboratory as the hospital units from which starting the digital transformation.

To summarise, a generic hospital aiming to successfully use digital technologies to cope with exploration and exploitation can start following—preferably in the clinical domain—the initial part of the path ① → ② in Figure 2.

– Figure 2. The paths to manage the exploration-exploitation paradox in healthcare –

Step 2: Assets Integration

Given that 12 of the 14 cases started this path, it was possible studying how hospitals tended to continue it. After appropriating the main benefits of initial digitisation investments, the solutions

introduced in the hospitals allowed the exploration of new, radical ways of providing healthcare services. For instance, H_2 started the digitisation of its radiology department mainly to reduce the usage of radiological films, save storage space and rationalise other resources used in this hospital unit. However, the progressive digitalisation of the various radiological devices (especially computed tomographies and magnetic resonance imaging) allowed to easily integrate their reports, opening up many possibilities of combining several layers of information in a comprehensive output, which not only increased the radiologists' capability to make new diagnoses, but also improved their efficiency and effectiveness.

Similar trends have been discovered in other hospitals that we have analysed, namely (see the e-companion for further details): (i) the queue management systems in H_4; (ii) the software virtualised in H_5; (iii) the laboratory devices in H_7. Initial investments supporting purely exploitatory activities and efficiency objectives opened up also exploration possibilities that, once seized, allowed not only to better balance the exploratory and the exploitatory efforts in the department (the final part of the path ① → ②), but also to increase its overall performance. As the CIO of H_4 stated:

> "*The benefits are only partially related to less paper-based processes. The real benefits are related to the fact that information circulates quickly, and users are empowered*".

Furthermore:

> "*We have always thought of ICT in terms of cost reduction. As a matter of fact, there are tremendous benefits also in terms of quality improvement*".

As suggested by cases of H_2, H_4, H_5 and H_7, the more the unit undergoing asset digitisation is detached from the rest of the hospital, the smoother and more successful the digitally-driven balance between exploration and exploitation. Problems encountered during the adoption, usage and improvement of the electronic queue management systems in H_4 and the virtualisation realised in H_5 traced back to the pervasiveness of these digital solutions and the number of processes affected by digitisation (see the e-companion for further details). Discussions with informants explained this evidence mostly in terms of "*protection of the unit*" (CIOs of H_2, H_4 and H_5).

Path B: Digitally-based Process Integration

Step 1: Internal Integration

Process integration can be realised in both clinical as well as administrative domains (Table 1). If clinical integration is almost completely accomplished through investments in an Electronic Medical Record (EMR) (IPI_3), administrative integration is realised through administrative and HR

management systems (IPI_1, IPI_2). In order to understand the value that hospitals extract through these integrations, the digital transformation ignited by the introduction of four different digital solutions in the *internal integration* area were compared (Tables 9-12, e-companion). Three cases (H_1, H_9, H_{14}) focused on EMR, while one (H_6) studied the introduction of an administrative management system.

In H_1, H_9, and H_{14} the introduction of an EMR allowed to: (i) improve the hospital's overall capabilities to explore and exploit, (ii) better balance exploration and exploitation at different levels (mainly hospital unit and whole hospital), (iii) achieve positive performance in terms of quality improvement and cost rationalisation. Indeed, the CMO of H_1 stated that:

> "*Our main focus was cost rationalisation. However, we ended also with a better service*".

Furthermore, as expressed by a physician at H_9:

> "*The final result? Better treatment, quicker diagnoses, and brand new research fields ready on the shelf waiting for us*".

On the other hand, as referred by the CIO of H_6:

> "*We need to rethink the workflows, together with the administrative staff, dematerialise more, and, then, review some choices in the system. It is a long, long way*".

H_6 faced many issues in producing an impact along these dimensions. These problems cannot be linked to the typology of the processes that H_6 decided to integrate. All informants highlighted that an integration realised among administrative processes should tackle fewer problems. Almost all hospitals accomplishing administrative integration (Table 3), invested in this area to collect what informants called "*quick wins*" between large waves of clinical integration. According to the cases, the real element able to explain different performance is the level of digitisation previously accomplished by the hospitals. H_1, H_9 and H_{14} had good percentages ($\geq$ 40%) of clinical documentation already dematerialised when they started implementing their EMR. Because of this gap, H_6 ran into many difficulties and the positive effect of asset integration within hospital units had not yet been explored.

There are multiple ways that allow switching from ② to ③ (Figure 2), and multiple combinations of exploration and exploitation—both realised through radical and incremental innovations. Rather than a standalone project, it is more common to proceed with a combination of sequential exploratory and exploitatory investments, as confirmed by Gastaldi et al. (2012).

Step 2: External Integration

Among the next steps to be accomplished after the introduction of an EMR, H_1, H_9 and H_{14} included extending the underlying integration outside them. The cross-analysis showed two complementary paths of external process integration (Figure 2). The first (EPI_1) is usually driven by the regional council and is based on developing an Electronic Health Record (EHR). The hospital has to answer the region's integration requests proactively—by making its EMR interoperable with other EMRs and/or following the guidelines released by the regional council on EMR development (Gastaldi and Corso, 2013). The second (EPI_2) is characterised by the hospital's efforts in directly connecting itself to its patients and general physicians. In order to understand if and how these paths allow hospitals to successfully manage the exploration-exploitation paradox, three digital transformations based on external process integration were compared (Tables 13–15, e-companion).

While introducing an EMR, H_3 also decided to better connect it to the regional EHR. The relative process is highly similar to the one accomplished by H_1 and ended in improved quality and lower costs (Adler-Milstein *et al.*, 2015; Lammers and Mclaughlin, 2016). However, these are only a small part of the potential benefits that it can achieve. In fact, CIO of H_3 stated that:

> "T*he integration with the EHR will bring tons of opportunities not only to further simplify things but also to discover new services to be offered to patients*".

Despite the tremendous potential, in order to be effective, the EHR requires years of exploratory and exploitatory investments by all the hospitals present in a region. Before the start of 2009, both H_{10} and H_{12} had already not only digitised and internally integrated most of their processes but also connected their EMR to the regional EHR (Table 3). This does not mean there are no more opportunities of external process integration. On the one hand, H_{10} engaged in the development of a telemedicine service for a specific typology of patients suffering from chronic obstructive respiratory disease. As referred by the CIO:

> "*Once you have data on the pathology you can better organise home visits, exams, etc., and, thus, you also decrease the overall costs of the treatment*."

H_{12}, on the other hand, developed a new channel to offer its services to its patients—through an application for latest-generation smartphones, and:

> "*these solutions are tremendously effective in engaging the patients and in getting close to them*" (as pronounced by the CMO of H_{12}).

In both cases, the relative digital transformation followed a similar logic showed before:

- an initial investment was accomplished in one direction (exploration for H_{10}, exploitation for H_{12}) which soon manifested opportunities in the other direction as well (exploitation for H_{10}, exploration for H_{12});
- by taking advantage of these opportunities, the hospital balanced the two conflicting activities and increased its quality while rationalising its costs.

As suggested by the cases, external integration also leads to a temporal separation between explorative and exploitative opportunities, hence supporting ambidexterity performance.

Path C: Disruptive Decision-making through Analytics

Step 1: Experimentation

The very first stimulus leading to investments in analytics was related to the informants' desire to explore new ways of extracting value from previously digitised administrative and clinical data. As depicted in Table 3, H_8, H_{11}, and H_{13}, all hospitals that invested in analytics, had high digital maturity in both clinical and administrative domain.

A cross analysis of the cases showed that the digital transformations pursued to progressively explore the potential of analytics are characterised by four elements. The first is an initial verticalisation in a pilot unit and/or in a functional area in order to: (i) protect development of the solution; (ii) facilitate the definition of the desired achievements and their measurement (as declared by the CEO of H_{11} "*once we have refined the algorithm, everything started to work smoothly, and results arrived*"); (iii) develop a solid base to be later extended to the rest of the hospital. Indeed, as stated by the CIO of H_8:

> "B*y focusing on a functional area we could have a niche in which to make things feasible and, at the same time, provide comprehensive benefits to all H_8*."

The second is the involvement of clinical (H_8 and H_{11}) and administrative (H_{13}) decision makers in the digital transformation—in order to compress the time needed for the overall cycle of collecting, analysing, acting and systematising clinical and/or administrative data. The third element is a progressive refinement of the underlying digital solution. The idea is to make it more effective in supporting decisions by exploiting different data sources, adopting more accurate algorithms, and making the user independent in their usage. The last element is an extension to the rest of the hospital. For instance, as referred by the CIO of H_{13}:

> "*The more you connect, the more digital data you can exploit to support decisions. The more you use digital data to support decisions, the more you need to connect the underlying resources producing these digital data. It is a sort of virtuous cycle that never ends*".

This extension is performed through a set of exploratory and exploitatory innovations—both of a radical and incremental nature—spanning multiple years. In fact, as stated by the CIO of H_{11}:

> "S*ince the very beginning, one has to be aware that the solution is part of a larger system that will be developed in the next years*."

As shown in Figure 2, hospitals started exploring the benefits of analytics only after a significant percentage of digitisation was accomplished (point ②). Informants underlined that the potential of analytics is stronger in the clinical domain than in the administrative domain. Solutions are realised in protected niches, in which the support to decision-making is progressively tested, and the disrupted way of performing the activities explored (② → ④).
Initially, and consistently with the disruptive innovation framework (Christensen, Grossman, and Hwang 2009), these experimentations tend to negatively affect both the exploitatory capability of the niche and its efficiency. Indeed, as explained by the CEO of H_{11}:

> "*Initially the results were not the ones [the CIO] promised. […] Time and money wasted*."

Informants said that these results are related to the fact that the disadvantages associated with these experimentations are not covered by the benefits generated by analytics (Davenport and Harris, 2007), which initially tend to produce only potential valuable scenarios of disrupted activities that have to be tested and progressively refined before being usable.

Step 2: Scaling-up

Test and refinement phases require a set of exploratory and exploitatory innovations (④ → ⑤) to be accomplished. The path ④ → ⑤ (Figure 2) aims simply to emphasise that the introduction of analytics is characterised by multiple combinations of exploratory and exploitatory innovation—both of an incremental and a radical nature. H_8, H_{11} and H_{13} adopted different combinations to balance exploration and exploitation. The common element to the digital transformations based on analytics that has been studied is the progressive improvement of: (i) capabilities to explore and exploit manifested by the hospital; (ii) performance achieved thanks to digital transformation—both in terms of quality and cost.

CHARACTERISATION OF THE THREE EMERGING PATHS

In this paragraph, we carry out a full IPO characterization of the three emerging paths (Table 4).

– Table 4. IPO characterization of three emerging paths –

The aim is twofold: first, to explain the intra-path elements on the basis of their IPO characterization; second, to feature comparisons among paths to unveil peculiar inter-path traits.

Path A: Assets Digitisation

In terms of *input*, Path A occurs at the unit level and most often in the clinical domain as clinical digitisation yields better results than administrative digitisation in effectively managing the exploration-exploitation paradox. Digitising assets represents a short-term strategy and requires a low use of digital capabilities. Hospitals undertaking this path are allowed to prioritise resources further to go through both Path B and Path C.

From the *process* viewpoint, antecedents give rise to a combined use of exploitation and exploration activities, with a prevalence of the former (from here, exploitation-driven balanced approach). This balanced configuration allows hospitals to move inside the efficiency frontier, where the two orthogonal dimensions of exploration and exploitation identify locally optimum trade-offs.

In terms of *output*, hospitals get sequential streams of incremental (first part of Path A) and radical (second part of Path A) innovations, accomplishing reasonable rates of quality improvement and cost rationalisation. Hospitals undertaking Path A improve their ability to observe the entire work process in action from "end to end" along with the capability to make decisions about next steps when alternative actions can be accomplished. It is true when the transition between the first part and the second part of Path A takes place, allowing hospitals to set up for appropriating the returns of more radical outcomes. It enables people inside the hospital unit to access and make sense of the requisite information collectively. Moreover, it makes the boundaries of hospital units more permeable yet able to be monitored. Finally, work practices may become more complex as people tend to apply their expertise to actual workflows rather than enact their jobs as separate functions.

Path B: Digitally-based Process Integration

In terms of *input*, Path B occurs at hospital level as all the units are integrated, involving both clinical and administrative domains. Integrating processes represents a medium-term strategy, requiring a moderate use of digital capabilities for the first part (② → ③). Instead, for the second part (③ → ⑤), a combination of operations support systems—aimed at integrating activities and decisions across agents of the healthcare ecosystem—and interpretation support systems—aimed at promoting partners' discovery and learning about inter-organisational relationships and its environment—is necessary. To this purpose, high levels of digital capabilities are necessary.

From the *process* viewpoint, these antecedents enable hospitals to pursue a balanced configuration of exploitation and exploration activities, co-evolving towards the EF and, using the modes of external process integration, pushing it further out in the exploration-exploitation space finding globally

optimum trade-offs. The digital integration among hospitals' processes and other agents seems to have a positive effect on the capability of a hospital to successfully balance exploration and exploitation (Gregory *et al.*, 2015).

In terms of *output*, hospitals tend to initially see sequential streams of incremental and radical innovations, which allow accomplishing good rates of quality improvement and cost rationalisation. Next, in the external process integration phase, they concretise the opportunity for structurally incremental and radical innovations as different subunits of different agents may, more or less simultaneously, accomplish the outcomes of explorative and exploitative activities. Cases show that, by following Path B, hospitals improve their overall capabilities to exploit and explore, reaching a better balance at different levels. Given the need to have already implemented Path A, hospitals can improve their ability to collaborate virtually by sharing and integrating each other's knowledge. Such a virtual collaboration highly depends upon intertwining technological and organisational features in ways that encourage open knowledge sharing and acquisition.

Path C: Disruptive Decision-making through Analytics

In terms of *input*, Path C occurs at the hospital level, mainly in clinical domains. Deploying an active support to decision-making is done by first disrupting the process with the introduction of analytics. This entails increased need for digital capabilities supported by interpretation support systems to make sense of data coming from the surrounding environment and leverage communication and collaboration with external agents. Then, in the second part of Path C (④ → ⑤), hospitals can scale-up their activities, this time lowering the need for digital resources and investments to a moderate level while maintaining high levels of digital capabilities. This path evolves in the long term, assuming that Path A has been already undertaken.

From the *process* viewpoint, these antecedents enable hospitals to pursue an exploration-driven balanced approach (② → ④) allowing hospitals to reach the efficiency frontier; in ④ → ⑤, hospitals push the efficiency frontier out while becoming truly ambidextrous and finding globally optimum trade-offs.

In terms of *output*, hospitals get sequential streams of incremental and radical innovations (④ → ⑤), going through punctuated discontinuities (② → ④) which give Path C its exploratory-driven connotation. The first part (② → ④) is necessary but not sufficient as this sequence of innovative outcomes would lead hospitals to become singular organic organisations with a high likelihood of failure as they may have many new products but little in the way of competence in realising their full innovative potential. By undertaking the second step, hospitals reach a good balance between exploration and exploitation activities while exploring new ways of extracting value from previously digitised administrative and clinical data. Increasingly better performance in terms of quality and cost trade-offs are realised.

DISCUSSION

In this paper, we focused on how solving the exploration-exploitation paradox in hospitals. Through an in-depth investigation, we disentangled inputs, processes, and outcomes of implementing digital transformation programs, their temporal attainment and configurations. Four contributions to the literature on the exploration-exploitation paradox emerge alongside specific propositions.

First, the exploration-exploitation paradox can be resolved undertaking digital transformation programs (Gregory *et al.*, 2015). The word paradox, especially in organisational settings, usually takes a negative stance implying contrasting aims, deep process rethinking, as well as mind set changing (Benner and Tushman, 2015). Instead, what is usually overlooked is that the underlying diversity and flexibility in being adopted allows not only to reconfigure exploratory-exploitatory efforts within and across healthcare stakeholders, but also to achieve better organisational performances—both in terms of cost reduction as well as quality improvement (Watson, 2015). However, a one-size-fits all solution is neither practicable nor desirable. Indeed, our study highlights three complementary paths which leverage upon a different exploration-exploitation balance, whose activities each of which impacting differently both innovation and efficiency outcomes. Each path, with its peculiarities, allows for different solutions to the exploration-exploitation paradox. Then, the first proposition follows:

Proposition 1: *hospitals can solve the exploration-exploitation paradox through the implementation of different digital transformation programs*.

Furthermore, the exploration-exploitation inputs were identified, being them on one side different digital solutions and, on the other side, strategic time frames (short, medium, long term). What is important, however, is the time-variant perspective (Piao *et al.*, 2010) we unveiled by showing how hospitals move along the identified paths and dynamically deal with the exploration-exploitation paradox. Short-time solutions are more exploitation-oriented (e.g., asset digitisation for Path A), whereas medium or long-term ones embrace more exploration-oriented activities (e.g., EMR and telemedicine services for Path B; analytics for Path C). Two reasons justify this difference: first, both Path B and C presumes the deployment of Path A; second, the digital solutions envisaged for Path B and C are more complex and require longer time frames to be accepted, understood, absorbed, and applied within the organisational context. A second proposition follows:

Proposition 2: *the implementation of digital transformation programs entails a time variant approach, where different time frames allow for different digital solutions*.

Regarding processes, we showed how hospitals deploy the exploration-exploitation (re)configurations (Simsek, 2009) in a space delimited by an efficiency frontier (EF). In the

exploration-exploitation space, depending on where hospitals position themselves and which digital solutions they adopt, the EF can be pushed further out. The reconfigurations can be exploitation-oriented as in the case of Path A, exploration-oriented as for Path C, as well as entailing a co-evolving balanced approach as for Path B (O'Reilly and Tushman, 2013). Path A paves the way for hospitals to implement Path B and/or Path C, pushing the EF further out (Birkinshaw and Gupta, 2013). The third proposition can be formulated as follows:

Proposition 3: *in case of asset digitisation, the efficiency frontier can be pushed further out by undertaking different exploration-exploitation (re)configurations.*

In terms of outcomes, we highlighted the degree of innovativeness achieved (Garcia and Calantone, 2002), the new ability to manage the exploration-exploitation paradox (Andriopoulos and Lewis, 2009), and the effect on the efficiency metrics namely, costs rationalisation and quality improvement (Smith and Lewis, 2011). Concerning the innovation outcomes, the three identified paths allow hospitals to intermittently innovate either in an incremental or radical/disruptive way. With the only exception of Path A, which is exploitation-driven because of the important efficiency stimulus to introduce into the organisation, Path B and Path C begin with a radical and disruptive step respectively. Each step brings also about different efficiency outcomes; however, both Path B and Path C are instrumental in reaching the highest cost rationalisation and quality improvements. Thus, we can advance the following proposition:

Proposition 4: *through different digital transformation programs, hospitals accomplish different innovation and efficiency outcomes*.

To sum up, our research provides theoretical contributions from several standpoints. First, the three paths constitute an example of the existing complementarity between exploitation and exploration, and highlight how alternating exploitative and explorative efforts allows the passage from ① to ⑤ (Piao, 2010). Second, the research is inserted within the academic debate regarding ambidextrous tensions in IT transformation programs. The study provides examples regarding the existing tension between costs and quality in IT portfolio decisions and combines it with the time dimension (Gregory *et al.*, 2015). Third, we investigated ambidexterity considering various levels of analysis spanning from the single department to the relationships between the hospital and the regional council (EPI_1) or the citizen and the general practitioner (EPI_2). Therefore, it is a step in the direction indicated by O'Reilly and Tushman (2013, p.333) regarding the need of works considering not only the single organisation but also the "firm's larger ecosystem". Fourth, the research describes different paths and the various possible effects in terms of costs or quality, or in terms of the degree

of innovativeness (Garcia and Calantone, 2002). Therefore, it is a contribution to the study of the relationships between ambidexterity and outcomes (Simsek *et al.*, 2009).

From the viewpoint of healthcare practitioners, the first contribution is the proof that digital transformation programs are a fundamental resource to resolve the tensions raised by the exploration-exploitation paradox. We have shown how to implement them may produce better performance. One has to consider that many CIOs encounter several issues in justifying to their strategic boards the importance of the expenditures in digital transformations. Also, very often hospital boards tend having confused ideas regarding the impact of digital technologies.

Another contribution of this research to healthcare organisations is the model depicted in Figure 2 to be used together with the IPO framework. Their combinations may orient managers in supporting those who want to strategically manage digital transformation in order to solve the exploration-exploitation paradox. It highlights important elements to consider when undertaking such changes: (i) the higher benefits associated with the application within the clinical domain, (ii) the selection of "protected" healthcare units to start the digitisation and/or the implementation of analytics, (iii) the risks associated with comprehensive digitisation attempts, (iv) the minimum level of document digitisation below which the digital integration and analytics are not effective, (v) the need to consider the time lapse present between digital installation and the achievement of a true disruptive potential.

This research also traces a link between the space in which the exploitatory-exploratory paradox emerges and time. Usually, institutions tend to associate exploitatory investments with the short term, and exploratory investments with the long term. Thus, they tend to over-emphasise exploitation at the expense of exploration because the former provides surer and more immediate results than the latter. The model allows the limitation of this potential problem through a continuous focus on combining exploitatory and exploratory investments—in short as well in the long term.

LIMITATIONS AND FUTURE RESEARCH

This paper does not come without limitations. The first one concerns generalisability. The focus on a specific lever (digital) and on a specific industry (healthcare), combined with the extensive use of interpretative studies, risks producing very idiosyncratic phenomena. As a further development, we could combine the interpretative methodology with a more quantitative-oriented set of vertical research that could formally test the effectiveness of proposed contributions in all their details in specific subfields. Furthermore, scholars could mix the findings of this research with a bibliometric or patent analysis, and contrast the sequence of digital technologies described by our model with the dynamics in the domain of digital technologies in healthcare that emerge through the study of publications or patents (Ardito *et al.*, 2017). The second limitation is related to the operationalisation of the constructs. Successful management of the exploration-exploitation paradox requires multidimensional concepts. The empirical analysis showed it is not straightforward to separate these

forces completely. Future studies could rely on variables that precisely measure: (i) the level of exploration and exploitation accomplished within and among hospitals; (ii) the performance achieved through their balance; (iii) the impact that digital technologies play in the achievement of the EF.

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FIGURES

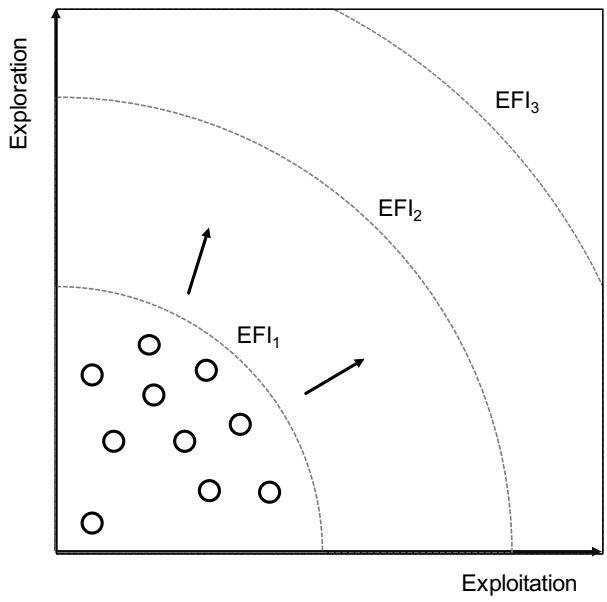

Figure 1. Efficiency Frontiers (EF) — Adapted from Birkinshaw and Gupta (2013)

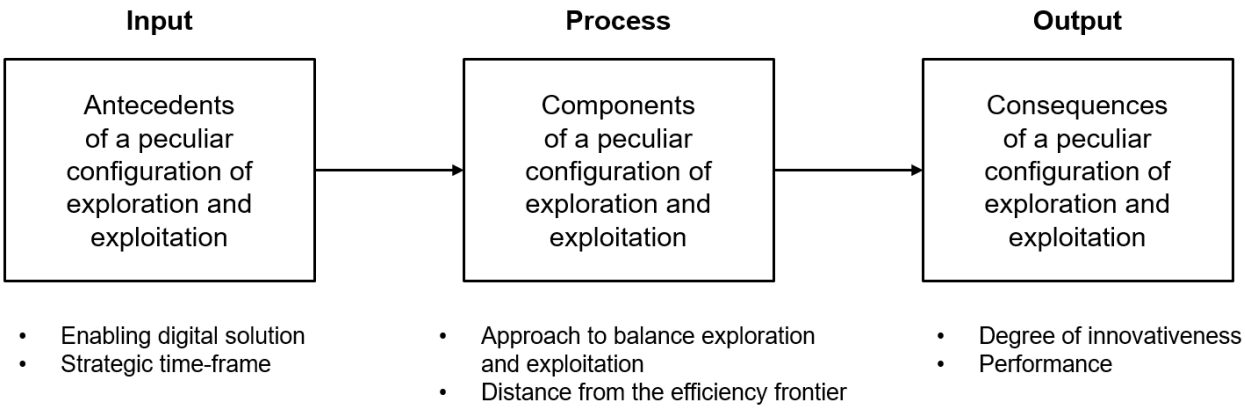

Figure 2. Input-Process-Output view of exploration and exploitation (adapted from Simsek, 2009)

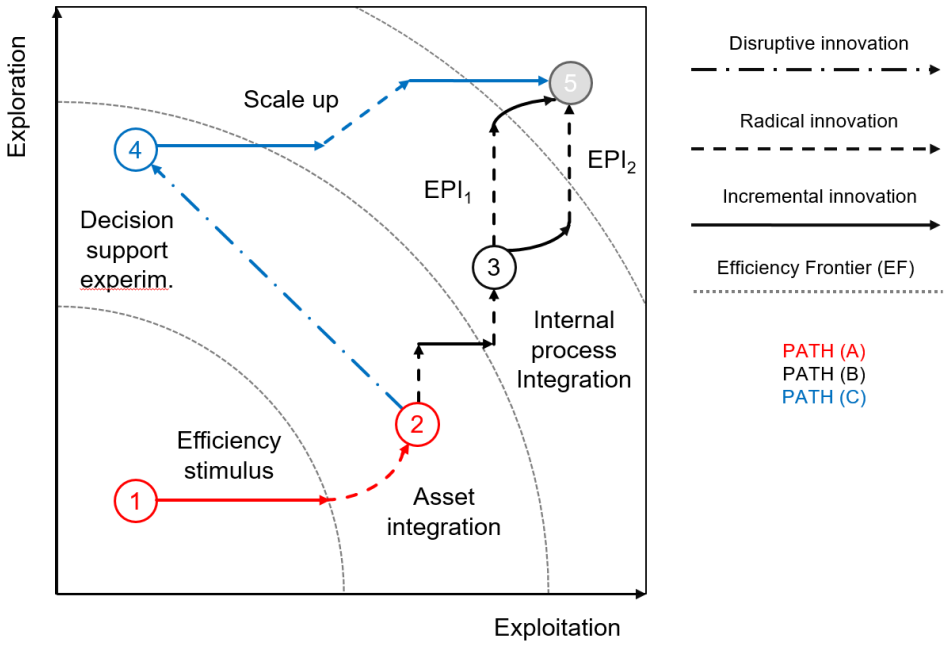

Figure 3. The paths to manage the exploration-exploitation paradox in healthcare

TABLES

Table 1. Digital solutions adopted by hospitals

Area	Id	Digital Solution	Definition*
Digitalisation	**DI_1**	Tools supporting service management and delivery	Digital solutions used in the admissions processes, in directing the user flows within the hospital, and in the communication that is oriented towards the users who are waiting for service delivery
	DI_2	IT security	Digital solutions guaranteeing the production of informational data, preventing access of unauthorised individuals and guaranteeing their access after catastrophic events
	DI_3	Virtualisation	Digital solutions that create a virtual version of HW, operating systems, storage devices or network resources
	DI_4	Systems for the dematerialisation of clinical documents	Digital solutions that allow to eliminate the paper-based or film-based documents that are used in a department, transforming them into electronic documents
	DI_5	Systems for the dematerialisation of administrative docs.	Digital solutions that allow to eliminate the paper-based documents used in the administrative offices of a HCO, transforming them into electronic documents
Internal process integration	**IPI_1**	Administrative management systems	Digital solutions for the management of accounting, financial flows, logistics, etc.
	IPI_2	Human resources management systems	Digital solutions used for the management of all aspects tied to the hospital's personnel (legal, economic, social, as well as attendances and absences, etc.)
	IPI_3	Electronic Medical Record	Digital solutions providing support to the computerised, uniform, updated and integrated management of personal, clinical data of a patient throughout the entire cycle of medical assistance given within the hospital
External process integration	**EPI_1**	Digital services to the patients	Digital solution to deliver services to the patients through digital channels; included in this category it is possible to find the communication services, those for patient access of clinical information, those supporting the use of healthcare resources, CRM services, and services to support the interaction among patients
	EPI_2	Regional medicine and home assistance	Digital solutions that respond to the aims of creating integration between the hospital, the district services and family doctors operating within the region
	EPI_3	Integration with the EHR	Digital solutions used to create integration with the platforms for Electronic Health Record, defined as the record format for healthcare data coming from various people in charge of treatment in the same territorial area
Analytics	**AN_1**	Computerised drug management systems	Digital solutions to support drug prescription, preparation and administration
	AN_2	Clinical Governance Tools	Digital solutions that support clinical decisions with the objective of improving the quality of services offered, and reaching/maintaining elevated healthcare standards (e.g. the systems to define diagnostic paths)
	AN_3	Governance dashboards	Digital solutions that support the governance/administrative decisions with the objective of improving the quality of the administrative processes (e.g. the business intelligence tools adopted to balance the peaks of demand)

Table 2. Hospitals involved in the case studies and interviews accomplished

Hospital*	Typology**	Employees	Ownership	Interviews to CIO	Interviews to CEO	Interviews to CFO	Interviews to CMO	Interviews to physicians and nurses	Total interviews
H_1	AO	3,608	Public	3	2	—	1	2	8
H_2	AO	2,320	Public	3	1	1	—	2	7
H_3	ASL	1,286	Public	4	2	1	—	2	9
H_4	ASL	3,256	Public	3	2	—	2	1	8
H_5	IRCCS	304	Private	3	1	1	1	1	7
H_6	IRCCS	783	Private	2	1	2	—	—	5
H_7	IRCCS	606	Public	3	1	1	1	2	8
H_8	AO	4,129	Public	3	2	1	1	1	8
H_9	AO	3,814	Public	4	2	1	1	2	10
H_{10}	ASL	805	Public	2	2	—	2	3	9
H_{11}	IRCCS	1,446	Public	3	1	—	1	1	6
H_{12}	IRCCS	641	Private	3	2	1	—	—	6

H_{13}	IRCCS	1,495	Private	3	2	2	—	—	7
H_{14}	IRCCS	3,826	Private	3	3	2	—	1	9

** Pseudonyms are used to protect the anonymity of the hospitals and their members*
*** AO (Azienda Ospedaliera): public hospital providing patient treatment by specialised staff and equipment as quasi-independent public agency; ASL (Azienda Sanitaria Locale): geographically-based hospital responsible for assessing needs and providing comprehensive care to the population of a defined territory; IRCCS (Istituto di Ricerca e Cura a Carattere Scientifico): hospital with competences in research and treatment of important diseases*

Table 3. Digital solutions characterising the digital transformation that has been studied

Hospital*	Digitalisation					Internal Process integration			External Process integration			Analytics		
	DI_1	DI_2	DI_3	DI_4	DI_5	IPI_1	IPI_2	IPI_3	EPI_1	EPI_2	EPI_3	AN_1	AN_2	AN_3
H_1		C		C	C	F		D[8]			F			
H_2		C	D	D[7]	C	C	C	F			F		F	
H_3	C		F	C		C		D	C		D[9]			
H_4	D[8]	D	C	C	C			F	C	F				
H_5		D	D[7]	C	C			F			F			
H_6		C	C	C	F	D[5]	C	C						C
H_7		D	C	D[8]	F			C	F					
H_8	C	C	C	C	D	C	D	C	C	F		C	D[8]	F
H_9		C		C	C	C		D[10]	F		F		F	
H_{10}		C	D	C	C	C	C	C	C	D[9]	C		F	
H_{11}	C	C	C	C	C	D	C	C	F	F	C	D[6]	C	
H_{12}	D	C	C	C	D	D	C	C	D[6]		C		F	F
H_{13}		C		C	C	D	C	C	C		C	C	F	D[7]
H_{14}		C	D	C	C	C	C	D[9]	F		D			F

** C means present at Jan. 2009; D means under development in the period from Jan. 2009 to Dec. 2011; F means development starting before the end of 2012 (but after the end of 2011); the digital solutions with squared parentheses are the one whose introduction process has been studied as the basis of the digital transformation ongoing into the hospital; the number within the parentheses indicates the number of interviews performed in the three years of the research*

Table 4. IPO characterisation of three emerging paths

Paths		(A) Asset digitalisation within hospitals	(B) Digitally-based process integration Internal	(B) Digitally-based process integration External	(C) Disruptive decision-making
Level of analysis		Hospital unit	Hospital	Healthcare systems	Hospital (mostly)
Input	Key enabling digital solution	Asset digitalisation (*low digital capabilities*)	EMR (*moderate digital capabilities*)	Telemedicine services (high *digital capabilities*)	Analytics (high *digital capabilities*)
	Strategic time-frame	Short-term	Medium-term	Medium-term	Long-term
Process	Balancing approach	Exploitation-driven balanced approach	Co-evolving balanced approach	Ambidextrous approach	Exploration-driven balanced approach
	Distance from the efficiency frontier	Inside the efficiency frontier	Reaching the efficiency frontier	Beyond the efficiency frontier	Beyond the efficiency frontier
Output	Degree of Innovativeness	Incremental and then radical innovation	Sequence of incremental and radical innovations		Disruptive innovation
	Performance	• *Initial*: moderate efficiency • *Final*: moderate efficiency and effectiveness	• *Initial*: moderate efficiency and/or effectiveness • *Final*: high efficiency and effectiveness		• *Initial*: inefficiency and ineffectiveness • *Final*: high efficiency and effectiveness

Input	Process	Output	Representative informants quotes
Digital solution: dematerialisation of radiological documents (DI_4) ***Stimuli to the adoption of the digital solution***: * • Reducing the usage of radiological films [***8.2***] • Saving storage space in the radiology department [***8.2***] • Save resources in the radiology department [***7.4***] ***Problems during the adoption phase***: * ** • *Major*: — • *Minor*: coordination with the supplier of the digital solution [**8.2**] • *Minor*: initial difficulties in the interactions with radiologists (understanding their needs) [***7.8***] • *Minor*: technical issues related to the digitalisation of radiologic assets [***7.7***]	***Development phases and impact on exploration and exploitation***: *** • Preliminary digitalisation of the main radiologic assets and simplification of radiologic routines [**EI | II**] • Development of a PACS to reduce film usage and refine radiologic workflows [**EI | II**] • Digital integration of the assets present in the radiologic dep. in order to produce new diagnoses [***EX | RI***] • Development of a full Radiology Information System (RIS) to efficient radiology workflows [***EI | RI***] • Implementation of a set of projects to fully explore the benefits of the shared data [***EX | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based asset integration (especially computer tomography and magnetic resonance imaging) • *Organisational level*: organisational differentiation between the radiology department and the rest of H_2	***Challenges/issues***: * • Compliance to regional and/or national rules (which are under development)—especially in terms of security [***8.4***] • Progressively switch from the logic of document dematerialisation to process dematerialisation [***7.2***] ***Performance impact***: * • *Initial*: reduction of time and cost per diagnosis [***9.0***] • *Final*: initial + improvement of diagnosis quality [***8.8***] ***Next steps to be accomplished***: * ***** • *Major*: continuing the integration among radiologic devices [***7.4***] • *Major*: dematerialising the documents and the processes of the laboratory [***7.6***] • *Minor*: Developing an Electronic Medical Record [***9.2***]	• *It's really difficult to capture the benefits of digital innovations such as EMR or analytics without a preliminary set of investments in infrastructure and digitalisation. Without a digital backbone, today a hospital is simply unavailable to generate value* **—CEO** • *My ICT investments should be transversal. I know it. But it's better to start where you know you can win* **—CIO** • *In this niche we can do whatever we want, while the rest of the hospital continues to work* **—CIO** • *Basically we dematerialise to cut costs* **—CEO** • *First you have to focus on clinical assets, and then on administrative ones. The reasons are mainly related to the higher value associated with clinical digitalisation* **—Chief radiologist** • *We are the "geeks" of physicians: we use digital stuffs and we value it... but I would never expect the results we have achieved simply connecting a computer tomography to a magnetic resonance imaging* **—Chief radiologist** • *The next steps? Simply one: let's continue on this nice "integration" road* **—Chief radiologist**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based asset integration; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 5. Main findings of the interviews performed on H_2

Input	Process	Output	Representative informants quotes
Digital solution: electronic queues management system (DI_1) ***Stimuli to the adoption of the digital solution***: * • Augmenting the efficiency of the front office employees in the admission processes [***9.0***] • Monitoring and reducing the queues in front of the admission desks (increasing the service level) [***10.0***] ***Problems during the adoption phase***: * ** • *Major*: — • *Minor*: coordination of the front-office employees scattered in the different facilities of H_4 and with different needs [**7.6**] • *Minor*: tender writing (to avoid the gathering of pure cost-oriented suppliers [**7.4**] • *Minor*: problematic purchasing [**7.6**]	***Development phases and impact on exploration and exploitation***: *** • Development of a set of interactive electronic multimedia kiosks to manage and standardise patient flow in the outpatient desk present in the main facility of H_4 [***EI | II***] • Extension of the multimedia kiosks to the outpatient desks of the other facilities of H_4 [***EI | II***] • Development of a solution to digitally integrate the different multimedia kiosks and provide a service coherent with patient behaviour [***EX | RI***] • Empowerment of front office employees with training on how to use the solution [***EI | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based asset integration • *Organisational level*: administered integration (among the front-office units) and domain differentiation (according to the kind of patient served)	***Challenges/issues***: * • Initial user resistance (digital tools seen only as a means to control their performance) [***9.2***] • Plurality of different stakeholders with different levels of digital readiness [***7.9***] ***Performance impact***: * • *Initial*: flexibility and synchronisation of service delivery [***7.7***] • *Final*: initial + increased quality of the healthcare service delivered [***7.7***] ***Next steps to be accomplished***: * ***** • *Major*: improving the communication to the patients during the queues [***8.0***] • *Major*: extending the solution to the exam booking processes [***8.6***] • *Major*: Further reducing the time spent in queues [***7.2***] • *Major*: Managing the outliers [***7.2***] • *Minor*: Developing an Electronic Medical Record [***8.0***]	• *The benefits are only partially related to less paper-based processes. The real benefits are related to the fact that information circulates quickly, and users are empowered* **—CEO** • *There are users who love PCs and users who simply hate them. I had to move within this "space". Trust me: it's not easy at all* **—CIO** • *Initially I thought "Just one more tech devilry", but I have to admit that the solution works, and it is useful* **—Nurse** • *Now we have a sort of triage for the different patients* **—Nurse** • *All this digitalisation is a prerequisite of EMR development* **—CIO** • *We have always thought of ICT in terms of cost reduction. As a matter of fact, there are tremendous benefits also in terms of quality improvement* **—CEO** • *Clinical data provides many more opportunities to both revise the existing paths through which the service of our organisation is delivered to our patients, as well as to change and improve these paths. Administrative processes are simply not such as pervasive as clinical processes in a hospital. It's a matter of impact* **—CMO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based asset integration; administered integration refers to the development of temporal reconfigurations of certain units in order to make possible the collaboration of resources necessary to solve the conflicts present between exploration and exploitation (Eisenhardt et al., 2010); domain differentiation means that each unit specialises in exploratory or exploitatory activities (e.g. standard patient treatment vs. acute patient treatment) while the hospital balance these activities across domains (Lavie et al., 2010).*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 6. Main findings of the interviews performed on H_4

Input	Process	Output	Representative informants quotes
Digital solution: virtualisation of hardware devices and the main clinical software (DI_3) ***Stimuli to the adoption of the digital solution***: * • Reducing the incidence of hardware and software obsolescence [***7.0***] • Improving scalability [***7.0***] • Centralising complex tasks in software and hardware management [***7.0***] ***Problems during the adoption phase***: * ** • *Major*: continuously raising requests from the healthcare departments [***8.0***] • *Major*: justification of digital budgets (difficulties in quantifying the benefits associated to digital solutions) [**7.2**] • *Major*: introduction of the solutions into existing processes (especially the clinical ones) [***8.9***]	***Development phases and impact on exploration and exploitation***: *** • Virtualisation of the main clinical software (standardisation and control over updates) [***EI | II***] • Hardware virtualisation (PCs as thin clients)—one dept. at a time [***EI | II***] • Integration of the virtualised software and development of new workflows and services (especially in the diagnostic area) [***EX | RI***] • Virtualisation of administrative software [***EI | II***] • Integration of administrative and clinical workflows [***EX | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based asset integration and temporal differentiation in the server farm hosting the virtualised solutions • *Organisational level*: organisational differentiation between the server farm and the rest of H_5	***Challenges/issues***: * • Business continuity issues [***7.7***] • Identity management [***7.2***] • Problems associated with the introduction of the virtualised solutions into existing processes (especially the clinical ones) [***8.0***] ***Performance impact***: * • *Initial*: reduction of HW and SW costs and health desk services [***9.1***] • *Final*: initial + better management of hardware and software evolutions/change [***8.6***] ***Next steps to be accomplished***: * ***** • *Major*: Developing an Electronic Medical Record and better integrating with the regional EHR [***8.3***] • *Major*: Considering cloud-based services for some general software to further decreasing costs and outsource their development [***7.8***] • *Major*: investing in digital security to guaranteeing access to server farms after catastrophic events [***7.2***]	• *Now there are no longer 1,000,000 different mail clients toward which to offer a helpdesk service* **—CIO** • *Now all the healthcare modules of the different solutions that were scattered in H_5 are in a unique place. And we can improve them for all the users* **—CIO** • *Now with my old-school PC I can run ultramodern apps!* **—Physician** • *These kinds of interventions are almost invisible to the final users. At best they do not notice anything* **—CIO** • *We are progressively entering into the digital world. One step a time. Our objective is start to implement an EMR by the end of 2012* **—CEO** • *It's better focusing on a department at a time. Why? Because it's possible to avoid the over-complications associated with the development of pervasive solutions—at least in the initial digitalisation stages and/or in the case of low budgets available* **—CIO** • *We have clearly missed an opportunity with digital… But we are aware of it, and we are in the process of changing this situation* **—CMO** • *We pay our digital ignorance…* **—CEO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based asset integration; temporal differentiation means that the service farm switches between exploration and exploitation over time; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 7. Main findings of the interviews performed on H_5

Input	Process	Output	Representative informants quotes
Digital solution: dematerialisation of laboratory documents (DI_4) ***Stimuli to the adoption of the digital solution***: * • Reducing the workload peaks of the laboratory (bottle neck for the other departments) [***8.7***] • Increasing the efficiency of the laboratory [***8.5***] • Being compliant to regional rules in terms of clinical dematerialisation [***7.1***] ***Problems during the adoption phase***: * ** • *Major*: high dependence of the other processes in the H_7 (pressures to dematerialise as soon as possible) [**7.9**] • *Major*: initial user resistance within the laboratory [**7.7**] • *Minor*: tender writing (definition of the specifications for the supplier of the digital solution) [**7.1**]	***Development phases and impact on exploration and exploitation***: *** • Preliminary digitalisation of the main laboratory assets and simplification of laboratory routines [***EI | II***] • Progressive refinement and improvement of laboratory workflows [***EI | II***] • Digital integration of the assets present in the laboratory in order to produce new diagnoses [***EX | RI***] • Development of a full Laboratory Information System (LIS) to efficient laboratory workflows [***EI | RI***] • Implementation of a set of projects to fully explore the benefits of the shared data [***EX | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based asset integration (especially order entry and specimen processing) • *Organisational level*: organisational differentiation between the laboratory and the rest of H_7	***Challenges/issues***: * • Physicians' resistance in using the tool to manage the analyses to be performed in the laboratory [***8.1***] • Progressively switching from the logic of asset dematerialisation to process dematerialisation [***7.1***] ***Performance impact***: * • *Initial*: reduction of the time and the cost per laboratory analysis [***8.2***] • *Final*: initial + improvement of the quality of the analyses carried out in the laboratory [***7.9***] ***Next steps to be accomplished***: * ***** • *Major*: continuing the dematerialisation in the laboratory [***9.0***] • *Major*: dematerialising the radiology department [***9.2***] • *Minor*: Digitalising the services through which the patients and the physicians interact with the laboratory [***7.0***] • *Minor*: dematerialising most of the administrative processes [***7.0***]	• *Do you know what slogans are used to convince us in investing in dematerialisation? Basically two: "We'll reduce costs", and "A rule obliges us to do it"* **—CEO** • *Radiology and laboratory are document-intensive departments, mostly detached by the core services offered by their hospital, with technology-friendly physicians, and many efficiency needs* **—CIO** • *There are three things to make clear: it's part of a bigger process, it's easier if you focus on one department at a time, and it has to start in a document-intensive department, like the laboratory* **—CIO** • *XXI century, here we are!* **—Physician** • *It's not simply an automated order entry. Now new analyses are available "on the shelf"…* **—CMO** • *The entire hospital was breathing down my neck, urging me to end the project as soon as possible. And I don't think that things will change for the radiology department* **—CIO** • *The time between the request of analyses and the delivery of their results is decreased* **—CIO**

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** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of IT/IS-based asset integration; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 8. Main findings of the interviews performed on H_7

Input	Process	Output	Representative informants quotes
Digital solution: Electronic Medical Record (IPI_3) ***Stimuli to the adoption of the digital solution***: * • Reducing the inefficiencies in clinical data management [***7.9***] • External pressures (integration with the Electronic Health Record) [***7.8***] • Improving the effectiveness of the treatments [***7.4***] ***Problems during the adoption phase***: * ** • *Major*: — • *Minor*: initial technological resistance of the physicians (used to work accordingly to own workflows) [***8.7***] • *Minor*: tender writing (previsions of the modular extensions; willingness to avoid pure cost-oriented vendors) [***7.7***]	***Development phases and impact on exploration and exploitation***: *** • Integration of the inter-departmental processes related to therapy management [***EI | RI***] • Implementation of a set of project in each department to use the shared data on therapies [***EX | II***] • Integration of the inter-departmental processes related to clinical dossier management [***EI | RI***] • Implementation of projects in each dept. to use clinical dossier [***EX | II***] • Integration of the inter-departmental processes related to out-patient management [***EI | RI***] • Implementation of a set of project in each department to use the shared out-patient data [***EX | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: temporal differentiation, administered integration	***Challenges/issues***: * • Balancing standardisation requirements with practitioners' customisation needs [***7.8***] • Managing user resistance [***8.3***] ***Performance impact***: * • *Initial*: cost rationalisation [***9.9***] • *Final*: initial + quality improvement [***9.8***] ***Next steps to be accomplished***: * ***** • *Major*: continuing the development of the EMR (focus on diagnostic area and Admission, Discharges and Transfers, ADT) [***8.4***] • *Minor*: better integrating with the regional Electronic Health Record (not only the mandatory data) [***7.6***] • *Minor*: developing an administrative management system [***7.1***]	• *My ideas are pretty clear. I know exactly what I want from an EMR and where we'll end. However, I have to take into account the annual resources in my hands. This solution is the best compromise I've found…* **—CIO** • *… and this "technician" comes to tell you that you have to change a decennial, effective way of working!* **—Physician** • *This year [2009] we integrate; the next one [2010] we'll start a verticalisation in each department to see how we can use the shared data. Then we'll restart the process of integration… and so on and so forth* **—CIO** • *To be honest, our main focus was cost rationalisation… but we ended also with a better service* **—CMO** • *EMR is on the agenda also for the year 2012* **—CEO** • *Not surprisingly, a great emphasis has been put on the management of the resistance of the physicians to the use of the electronic tool. I know my hens, and I expected that reaction* **—CMO** • *At the end of the story he [referring to the CIO] was right. Goddam! [laughing] He was right…* **—Physician**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise EMR adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration; temporal differentiation means that the hospital switches between exploration and exploitation over time; administered integration refers to the development of temporal reconfigurations of certain units in order to make possible the collaboration of resources necessary to solve the conflicts present between exploration and exploitation (Eisenhardt et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 9. Main findings of the interviews performed on H_1

Input	Process	Output	Representative informants quotes
Digital solution: Administrative management system (IPI_2) ***Stimuli to the adoption of the digital solution***: * • Reducing the inefficiencies in the management of administrative data [***8.7***] • Improving the effectiveness of healthcare management [***8.3***] • External pressures (more effective management of prospective payment) *** [***8.1***] ***Problems during the adoption phase***: * ** • *Major*: extreme heterogeneity of the current applications [***7.6***] • Major: highly disconnected resources in the administrative units [***7.6***] • *Major*: lack of sponsorship from the strategic board [***7.6***]	***Development phases and impact on exploration and exploitation***: *** • Initial workflow review and automation [***EI | II***] • Implementation of the administrative management system [***EI | RI***] • Revision of the main administrative workflows in order to make them compliant to the new solution [***EI | II***] • Digitalisation of the assets characterising the administrative processes [***EI | II***] • Re-implementation of the administrative management systems [***EI | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • No ambidextrous approach • Limited impact on the capability to explore • Limited impact on the capability to exploit • Main cause: lack of a preliminary digitalisation	***Challenges/issues***: * • Reviewing most of the administrative processes [***9.2***] • Managing user resistance (related to the changes in the workflows) [***9.0***] • Increasing the sponsorship of the initiative [***8.2***] ***Performance impact***: * • *Initial*: workflow automation (only partial reduction of administrative inefficiencies) [***8.0***] • *Final*: negative impact on the effectiveness of healthcare management (cumbersome workflows) [***8.6***] ***Next steps to be accomplished***: * ***** • *Major*: introducing a solution to dematerialise the administrative documents [***7.8***] • *Major*: review the workflows with the administrative staff [***8.8***] • *Major*: review the administrative management system [***9.2***]	• *I could tell you that we want to introduce it to be a little bit more effective than today… I would tell only part of the truth. Our main focus is to keep costs under control* **—CFO** • *It's incredible how cumbersome an administrative process can be* **—CIO** • *Problems have a cultural, organisational and technical nature. As a consequence, a triple somersault is needed* **—CIO** • *Perhaps we've bit off more than we can chew* **—CEO** • *We need to rethink the workflows, together with the administrative staff, dematerialise more, and, then, review some choices in the system. It's a long, long way [sigh]* **—CIO** • *This heterogeneity? It is the result of years of ad hoc, patchy developments in the administrative applications… How can we explain it? Partially is the reflection of a lack of vision and a difficult context in which developing ICT, partially we have to "blame" the difficulties tackled day by day and the operative workload* **—CIO** • *We have wasted money…* **—CFO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise EMR adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Since the last reform of the Italian healthcare system, in 1999, all the Italian hospitals are financed by a predefined overall budget composed of two elements: (**i**) payment for inpatient and outpatient care by means of predetermined rates based on DRG (Diagnosis-Related Group), and (**ii**) payment based on the average production cost for emergencies, care activities with high waiting costs, prevention schemes, social services, transplant activities and management of chronic illness. Recent evaluations of the impact of DRG system in Italy (e.g., Ferré et al., 2014) have shown that the introduction of a prospective payment system has led to a greater attention to planning and budgeting within each hospital*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 10. Main findings of the interviews performed on H_6

Input	Process	Output	Representative informants quotes
Digital solution: Electronic Medical Record (IPI_3) ***Stimuli to the adoption of the digital solution***: * • Improving the effectiveness of the treatments [***8.8***] • External pressures (EHR integration) [***7.6***] • Reducing the inefficiencies in clinical data management [***7.1***] ***Problems during the adoption phase***: * ** • *Minor*: decision from which department to start (efficiency vs. potential pervasiveness) [***7.2***] • *Minor*: clearly understand the necessities of the physicians [***7.8***] • *Minor*: technical problems linked to the customisation of the EMR to the workflows of the pilot department and the interoperability issues [***7.6***]	***Development phases and impact on exploration and exploitation***: *** • Integration of the processes of the paediatric intensive care to explore new treatments/diagnoses [***EX | RI***] • Implementation of a set of projects to share the new treatments/diagnoses to the rest of H_9 [***EI | II***] • Integration of the processes of cardiology to explore new treatments/diagnoses [***EX | RI***] • Implementation of a set of projects to share the new treatments/diagnoses to the rest of H_9 [***EI | II***] • Integration of the processes of the emergency department to explore new treatments/diagnoses [***EX | RI***] • Implementation of a set of projects to share the new treatments/diagnoses to the rest of H_9 [***EI | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: temporal differentiation and emergent integration	***Challenges/issues***: * • Balancing practitioners' customisation needs with standardisation requirements [***7.2***] • Homogenising the different sections of the EMR [***8.6***] ***Performance impact***: * • *Initial*: quality improvement [***8.5***] • *Final*: initial + cost rationalisation [***7.9***] ***Next steps to be accomplished***: * ***** • *Major*: better integrating the patients to the healthcare processes—offering digital services through the site of the hospital [***8.3***] • *Major*: developing a clinical governance support system (extracting value from the digital data) [***8.5***] • *Major*: continuing the development of the EMR (focus on the neurology and oncology departments) [***8.0***]	• *One by one we make all of them happy! Seriously: a focus on each department—combined with a good overall design—allows us to understand and better meet the demands from the business lines* **—CIO** • *We are simply doing what we have done within each department. But on a bigger scale. Information has to be available everywhere if you want to truly achieve the relative benefits* **—CEO** • *Standardisation? it was a bloodbath, but it was worth it* **—CIO** • *The end results? Better treatment, quicker diagnoses, and brand new research fields ready on the shelf waiting for us* **—Physician** • *The risk is to create a set of fantastic islands with kilometres of sea separating them* **—CMO** • *The unique rejection issues are encountered once you try to extend the "tailored" feature to other departments. In these cases, some revisions are necessary* **—CIO** • *The next piece in this jigsaw is the patient. We need to better integrate out patients to our hospitals* **—CEO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise EMR adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration; temporal differentiation means that the hospital switches between exploration and exploitation over time; emergent integration means that the department spontaneously and often serendipitously activate cross-department collaborations to cope and progressively solve the conflicts present between exploration and exploitation (Martin and Eisenhardt, 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 11. Main findings of the interviews performed on H_9

Input	Process	Output	Representative informants quotes
Digital solution: Electronic Medical Record (IPI3) ***Stimuli to the adoption of the digital solution***: * • Improving the effectiveness of the treatments [***9.1***] • Reducing the inefficiencies in clinical data management [***8.7***] • External pressures (EHR integration) [***7.3***] ***Problems during the adoption phase***: * ** • *Major*: diffused pressures to realise the EMR as soon as possible (necessities of data-sharing among physicians) [***9.1***] • *Major*: engagement by the whole organisation (both the creation as well as the maintenance during the adoption) [***8.2***] • *Major*: managing the change management process (especially its initial communication) [***10.0***]	***Development phases and impact on exploration and exploitation***: *** • Process integration in the diagnostic area of emergency department [***EI | II***] • Focus on the digitalisation of clinical dossier management [***EX | RI***], starting by the digitally-based integration of the emergency department and radiology [***EI | RI***] • Integration of the processes of the laboratory and exploration of new treatments/diagnoses [***EX | RI***] • Macro integration of the inter-departmental processes related to out-patient management [***EI | RI***] • Implementation of a set of projects to (i) fully explore the benefits of the shared data [***EX | II***] and (ii) extend the new treatments/diagnoses to the rest of H14 [***EI | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: domain differentiation, heuristic-based integration	***Challenges/issues***: * • Financial exposure (resolution: cost compression with hardware virtualisation) [***9.3***] • Maintaining engagement during the change management process (resolution: mixture of eLearning and Face-to-Face training) [***8.6***] ***Performance impact***: * • *Initial*: — [***6.7***] • *Final*: cost rationalisation and quality improvement [***8.2***] ***Next steps to be accomplished***: * ***** • *Major*: better integrating the patients to the health care processes—offering digital services through the site [***7.8***] • *Major*: developing a set of governance dashboards (extracting value from the digital data) for the management of the HCO [***8.2***] • *Major*: continuing the development of the EMR (focus on ADT management, and neurology process integration) [***8.6***]	• *I was tired of hearing from every physician I meet how "it would be great to have an EMR". I knew it! […] But now we have these conditions. I thought: let's shut them up once and for all!* —**CIO** • *Engagement is everything in such projects; and everything has to start from the board* —**CEO** • *With these kinds of solutions you simply cannot adopt a "big-bang" go-live* —**CIO** • *Let me tell you one thing: being an IRCCS doesn't simplify things...* —**CIO** • *If you want to train more than 2,000 employees, eLearning is a mandatory road… but we've combined with eLearning a smart, face-to-face "train-the-trainer" approach* —**CEO** • *When I looked at the budget and the investment plan I threw my hands up in despair [laugh]* —**CFO** • *We had to run like a sprinter, but now we have a full EMR* —**CEO** • *The entire hospital was breathing down my neck, urging me to end the project as soon as possible* —**CIO** • We didn't have many more alternatives to improve our service to patients. EMR was simply unavoidable…. —**CMO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise EMR adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration; domain differentiation means that each unit specialises in exploratory or exploitatory activities in particular domain (e.g. standard patient treatment vs. acute patient treatment) while the hospital balances these activities across domains (Lavie et al., 2010); heuristic integration means that exploration and exploitation are integrated through the usage of a portfolio of deliberately small set of articulated and often informal rules-of-thumb (Eisenhardt et al., 2010; Bingham and Eisenhardt, 2011)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 12. Main findings of the interviews performed on H14

Input	Process	Output	Representative informants quotes
Digital solution: Integration with the regional Electronic Health Record (IPI_3) ***Stimuli to the adoption of the digital solution***: * • External pressures (EHR integration) [***8.0***] • Reducing the inefficiencies in clinical data management [***8.2***] • Improving the effectiveness of the treatments [***8.4***] ***Problems during the adoption phase***: * ** • *Major*: — • *Minor*: initial technological resistance of the physicians (used to work according to own workflows) [**7.9**] • Minor: budget negotiation with the strategic board [***7.3***] • Minor: problems in the initial phases of the relationship with the supplier of the digital solution (especially in explaining the needs of H_3) [***7.5***]	***Development phases and impact on exploration and exploitation***: *** • Integration of the inter-departmental processes related to clinical dossier [***EI | RI***] • Integration to the clinical dossier of the EHR of the Region [***EI | II***] • Implementation of a set of projects in each department to use clinical dossier data [***EX | II***] • Integration of the inter-departmental processes related to therapy management [***EI | RI***] • Integration to the regional therapy management file [***EI | II***] • Implementation of a set of project in each department to use the shared data on therapies [***EX | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: temporal differentiation, administered integration • *Regional level*: digitally-based process integration	***Challenges/issues***: * • Privacy and security concerns (due to the presence of an external actor in the system) [***7.5***] • Balancing standardisation requirements with practitioners' customisation needs [***8.0***] ***Performance impact***: * • *Initial*: EHR integration and cost rationalisation [***8.6***] • *Final*: initial + quality improvement [***9.0***] ***Next steps to be accomplished***: * ***** • *Major*: virtualising hardware and software (cost compression) [***7.5***] • *Minor*: continuing both the development of the EMR as well as the integration with the EHR [***7.1***] • *Major*: developing a clinical governance support system (extracting value from the digital data) [***8.2***]	• *I really risked having a fistfight with Mr. X [the CIO] for the financing of the project [laugh]* **—CFO** • *I though: OK we want to implement an EMR, why don't we exploit the opportunity also to better integrate with the regional EHR?* **—CEO** • *I've learnt that adhering to an EHR involves many issues in terms of privacy and security* **—CIO** • *Budget constraints force us to think about a virtualisation to compress costs* **—CIO** • *Initially I was extremely sceptical. I'm not such a "PC-aholic"… Well, I was wrong* **—Physician** • *This is only the tip of the iceberg. The integration with the EHR will bring tons of opportunities not only to further simplify things, but also to discover new services to be offered to patients* **—CIO** • *There are plenty of things that we have to do… The road in front of us is still very long* **—CEO** • *Let's focus on therapy management area. I have registered a compression of costs of an order of 25%. Unbelievable.* **—CFO** • *The results in a nutshell? Less errors, less costs, and processes under control* **—CEO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration; temporal differentiation means that the hospital switches between exploration and exploitation over time; administered integration refers to the development of temporal reconfigurations of certain units in order to make possible the collaboration of resources necessary to solve the conflicts present between exploration and exploitation (Eisenhardt et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 13. Main findings of the interviews performed on H_3

Input	Process	Output	Representative informants quotes
Digital solution: telemedicine service (EPI_2) ***Stimuli to the adoption of the digital solution***: * • Improving the effectiveness of the treatments offered to chronic patients [***8.6***] • Improving the efficiency in providing treatment to chronic patients [***8.9***] • Decentralising the healthcare service [***7.6***] • Providing a healthcare service in the territory under the responsibility of H_{10} (which is an ASL, see Table 1) [***8.0***] ***Problems during the adoption phase***: * ** • *Major*: installation of the necessary hardware and software at the homes of the chronic patients [**9.0**] • *Major*: managing privacy and security issues [**10.0**] • *Minor*: training to the family of the chronic patients [**8.3**]	***Development phases and impact on exploration and exploitation***: *** • Selection of the target chronic patients and installation of the necessary hardware/software to deliver the telemedicine service [***EX | RI***] • Progressive digitalisation of the processes to fully deliver the telemedicine service [***EI | II***] • Improvement of the solution based on the evidences collected by the sensors installed in patient's house [***EX | II***] • Development of new treatments exploiting the integration of the assets installed in patient's house with the one in the facilities of H_{10} [***EI | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: organisational diff. (pilot unit vs. the rest of H_{10}) • *Regional level*: digitally-based process integration	***Challenges/issues***: * • Privacy and security concerns (due to the presence of an external actor in the system) [***9.8***] • Organisation of the home visits [***8.9***] • Maintenance of the solution [***7.6***] ***Performance impact***: * • *Initial*: decentralising the healthcare services and augmenting the quality of the treatment (less mortality rate) [***9.6***] • *Final*: initial + decreasing of the cost of the treatment [***8.6***] ***Next steps to be accomplished***: * ***** • *Minor*: extending the pilot group of chronic patients treated via telemedicine [***9.2***] • *Major*: starting a new telemedicine project on another typology of chronic patients [***8.1***] • *Major*: developing a clinical governance support system (extract value from the digital data) [***7.8***] • *Minor*: virtualising hardware and software (cost compression) [***7.1***]	• *Then we involved the CIO, but everything started here* **—Physician** • *Most of the hindrances have a privacy label, it's true. However, the competences of the involved stakeholders are equally critical* **—Physician** • *I had a hard row to hoe with this project, but looking back… Wow! What a result* **—CIO** • *Once you have data on the pathology you can better organise home visits, exams, etc., and, thus, you also decrease the overall costs of the treatment. And we are talking about a chronic disease!* **—CMO** • *Whit this project we have saved 12 beds in intensive care* **—CMO** • *Our plan is to double the pilot group by the end of 2012* **—CEO** • *Often these projects remain nice experimentation. We have overcome this step. The solution is here to stay* **—CIO** • *The benefits of internal integration soon reach their potential, and the Lombard EHR is not developed enough to further improve our services* **—CIO** • *ICT automates significant parts of hospital processes, and brings completely new services that permanently change the way healthcare is provided* **—CEO**

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** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 14. Main findings of the interviews performed on H_{10}

Input	Process	Output	Representative informants quotes
Digital solution: mobile health services for patients (EPI_1) ***Stimuli to the adoption of the digital solution***: * • Better connecting to the patients [***8.2***] • Reducing the inefficiencies in clinical data management [***7.8***] • Improving the effectiveness of the healthcare service (both the core as well as the support activities) [***8.8***] ***Problems during the adoption phase***: * ** • *Major*: managing privacy and security issues [**9.2**] • *Major*: integration of the mobile solution in the existing workflows (partial workflow redesign) [**8.7**] • *Minor*: technical problems in the interaction of the solution with information systems of H_{12} [**7.9**]	***Development phases and impact on exploration and exploitation***: *** • Preliminary digitalisation of the basic processes characterising the interaction with the patients [***EI | II***] • Development of a mobile app for allowing patients to book exams, and pilot over a niche of technology-friendly patients (less than 35 years old) [***EX | RI***] • Progressive improvement of the mobile app with other functionalities (e.g. allowing patients to access their data and review reports) [***EI | II***] • Development of a marketing campaign to extend the solutions to all the patients of H_{12}, and training regarding how to use the solutions effectively [***EI | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: digitally-based process integration • *Organisational level*: digitally -based process integration • *Regional level*: digitally -based process integration	***Challenges/issues***: * • Privacy and security concerns (due to the presence of an external actor in the system) [***8.8***] • Compliance to a set of regional rules that are under development [***8.4***] • Extension of the solution to all the patients of H_{12} [***9.2***] ***Performance impact***: * • *Initial*: decreasing the cost of the healthcare service [***8.9***] • *Final*: initial + decentralising the healthcare services and augmenting the proximity to the patients [***8.8***] ***Next steps to be accomplished***: * ***** • *Major*: exploration of further ways to better integrate with the patients and/or general physicians [***9.2***] • *Major*: developing a clinical governance support system (extract value from the digital data) [***10.0***] • *Major*: developing a set of governance dashboards (extracting value from the digital data) for the management of H_{12} [***9.8***]	• *Everything around health care is changing. People use social networks and instant messaging instead of emails. Patients want to access their data on the run, with their mobile phones. We felt the necessity to adapt to this brand new digital world out there. Health IT is not simply a matter of EMR…* **—CIO** • *Patients do not care about EMR or EHR. Patients do not know what these acronyms mean. Patients want Apps. Patients are increasingly used to live online, and want—for instance—to visualise a report on their smartphones* **—CEO** • *"Customer experience" and "virtual workspace" are the new cornerstones in healthcare* **—CIO** • *These solutions are tremendously effective in engaging the patients and in getting close to them.* **—CMO** • *The EHR will be an incredible tool once completed. Will… Note the tense. We need to offer better services to our patients now. We simply cannot afford to go at a snail's pace* **—CEO** • *The mobile app has contributed not only to cut costs—as [the CFO] can confirm—, but also—and especially—in increasing our proximity to the patients* **—CMO** • *For many patients the app is already a "must have"* **—CEO**

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** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; refers to §4 for a description of digitally-based process integration*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 15. Main findings of the interviews performed on H_{12}

Input	Process	Output	Representative informants quotes
Digital solution: clinical governance tools (AN_2) ***Stimuli to the adoption of the digital solution***: * • Extracting value from the digitalised clinical documents [***9.6***] • Actively supporting clinical decision-making [***7.8***] • Starting an experimentation in the promising field of analytics [***8.0***] ***Problems during the adoption phase***: * ** • *Major*: — • *Minor*: comparisons between documents with a different nature [**7.2**] • *Minor*: initial collaboration between clinicians and digital experts [**9.0**] • *Minor*: integration of the solution into the workflows relative to the pneumonia diagnosis [**7.7**]	***Development phases and impact on exploration and exploitation***: *** • Selection of "pneumonia diagnosis" as a pilot functional area, and data mining on historical data to create 12 different pneumonia cases with the relative antecedents [***EX | DI***] • Knowledge systematisation with the progressive integration of data from other departments [***EI | II***] • Development of an active form of support to decision making using the developed knowledge [***EX | RI***] • Extension to the new pneumonia diagnosis to the rest of H_8 [***EI | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: domain differentiation (pneumonia diagnoses and other diagnoses) and temporal differentiation, both facilitated by digital solutions • *Organisational level*: initially organisational differentiation; then heuristic-based integration	***Challenges/issues***: * • Switching from passive to active decision support [***7.8***] • Formalisation and standardisation of the new knowledge created [***8.2***] ***Performance impact***: * • *Initial*: — [***7.6***] • *Final*: improvement of the appropriateness and waste reduction during the treatment [***8.8***] ***Next steps to be accomplished***: * ***** • *Minor*: extensions to another functional area (pulmonary embolism) [***7.8***] • *Major*: experiment a telemedicine project for chronic cardiovascular patients [***7.8***] • *Major*: developing a set of governance dashboards (extracting value from the digital data) for the management of H_8 [***9.2***]	• *We have tons of unused clinical data. I don't believe that we have digitalised them only to accomplish our EMR. We can make use of them to improve our decisions, and this project simply starts doing it* **—CEO** • *We thought that by focusing on a functional area we could have a niche in which to make things feasible and, at the same time, provide comprehensive benefits to all H_8* **—CIO** • *In my view this is not analytics. Not yet. For the moment we have "just" performed some statistical analyses, and some knowledge extrapolation. The next step is to bring a true active form of decision-support* **—CIO** • *We are thinking to a telemedicine solution for some of our cardio-vascular patients* **—CMO** • *Solutions like this one tremendously improve the appropriateness of our treatments. It's not my opinion. Now we have plenty of data supporting my claim* **—CEO** • *To be honest it took more than I thought in order to see the first benefits* **—CIO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; domain differentiation means that each unit specialises in exploratory or exploitatory activities in particular domain (e.g. pneumonia diagnoses vs. non-pneumonia diagnoses) while the hospital balances these activities across domains; temporal differentiation means that the hospital switches between exploration and exploitation over time (Lavie et al., 2010); organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010); heuristic-based integration means that exploration and exploitation are integrated through the usage of a portfolio of deliberately small set of articulated and often informal rules-of-thumb (Eisenhardt et al., 2010; Bingham and Eisenhardt, 2011)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 16. Main findings of the interviews performed on H_8

Input	Process	Output	Representative informants quotes
Digital solution: computerised drug management system (AN_1) ***Stimuli to the adoption of the digital solution***: * • Extracting further value from the healthcare data previously digitalised and integrated [***7.6***] • Improving the quality of the prescriptions of the physicians [***8.1***] • Simplifying and reducing the efforts in drugs prescription [***8.3***] ***Problems during the adoption phase***: * ** • *Major*: lack of shared standards on which to base the development and the refinement of the algorithm used to support decisions (due to a strong heterogeneity in the correlation tables among available drugs, allergies and tolerances) [**9.2**] • *Minor*: initial user resistance [**8.1**] • *Minor*: managing the inefficiencies relative to the introduction of the solution into the department [**8.9**]	***Development phases and impact on exploration and exploitation***: *** • Development of a pilot solution to alert the physicians of the intensive care department in case of dangerous prescriptions (suggestions based on known interactions among different drugs) [***EX | DI***] • Refinement of the decision-support algorithm within the department [***EI | II***] • Improvement of the algorithm with data from other departments [***EX | II***] • Extension of the solution to the Gastroenterology dep. [***EI | RI***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: temporal and domain differentiation, both facilitated by the presence of the digital solution • *Organisational level*: initially organisational differentiation between the department and the rest of H_{11}, then heuristic-based integration	***Challenges/issues***: * • Increasing the support delivered by the solution to decision-making [***7.6***] • Progressively extending the solution to the other departments [***8.1***] • Improving solution usability [***9.0***] • Justifying the amount of budget delivered to the solution [***7.1***] ***Performance impact***: * • *Initial*: inefficiencies in the pilot department (controls of the decision-support capability of the solution [***8.3***] • *Final*: efficiency and effectiveness in the pilot department and H_{11} [***7.9***] ***Next steps to be accomplished***: * ***** • *Major*: progressive extension of the solution to other departments [***8.5***] • *Minor* finishing the revision of the administrative management system [***7.7***] • *Major*: continuing the development of a virtual network to connect the oncologic patients not only each other, but also to specialised physicians within and outside H_{11} [***7.2***]	• *Since the very beginning, one has to be aware that the solution is part of a larger system that will be developed in the next years* **—CIO** • *The Extract-Transform-Load process is always complex—especially in a IRCCS. I knew it. What I didn't know was that it will cost so much* **—CIO** • *The decision-support is far away more effective when data is available from multiple sources* **—Physician** • *Obviously you cannot expect a "magic" effect, but only good help. Digital technologies will never replace physicians. Digital will simplify physicians' lives, allowing them to focus on what matters: care* **—Physician** • *The time needed for collecting, analysing and acting on the data must be reduced. Not only in drug prescription. Everywhere* **—CEO** • *This virtual network connecting patients to physicians is one of the best things I've ever seen* **—CMO** • *Initially the results weren't the ones [the CIO] promised. I remember that I though: "time and money wasted". Once we have refined the algorithm, everything started to work smoothly, and results arrived*— **CEO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*

** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*

*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*

**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; temporal differentiation means that the hospital switches between exploration and exploitation over time; domain differentiation means that each unit specialises in exploratory or exploitatory activities in particular domain while the hospital balances these activities across domains; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010); heuristic-based integration means that exploration and exploitation are integrated through the usage of a portfolio of deliberately small set of articulated and often informal rules-of-thumb (Eisenhardt et al., 2010)*

***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 17. Main findings of the interviews performed on H_{11}

Input	Process	Output	Representative informants quotes
Digital solution: governance dashboards (AN_3) ***Stimuli to the adoption of the digital solution***: * • Extracting value from the administrative digitalised documents [***7.8***] • Increasing the level of governance of H_{13}, especially considering the presence of different facilities [***8.1***] • Enhancing asset management [***7.3***] ***Problems during the adoption phase***: * ** • *Major*: necessity to complete the project in short time (pressures to have the solution available as soon as possible) [**8.3**] • *Minor*: construction of a user-friendly interface allowing autonomous data exploration [**8.9**] • *Major*: technical issues due the level intricacy of the administrative processes (ETL process implementation) [**7.4**]	***Development phases and impact on exploration and exploitation***: *** • Development in the main facility of H_{13} of a dashboard to correlate and explore administrative data relative to quality management [***EX | DI***] • Extensive testing and refinement of the solution with a set of power users within the main facility of H_{13} [***EI | II***] • Improvement of the dashboard with the usage of all the other administrative data of H_{13} [***EX | RI***] • Extension of the solution to all the other facilities of H_{13} [***EI | II***] ***Approaches to manage the exploration-exploitation paradox***: **** • *Departmental level*: temporal and domain differentiation, both facilitated by the presence of the digital solution • *Organisational level*: initially organisational differentiation, then heuristic-based integration	***Challenges/issues***: * • User resistance (solution: on-the-job training of the power-users on how to use the solution) [***8.0***] • Extension of the solution to all the facilities of H_{13} [***8.0***] ***Performance impact***: * • *Initial*: general inefficiencies [***10.0***] • *Final*: improvement in the autonomy of managers in exploring data, in the quality and in the efficiency of their decisions [***9.8***] ***Next steps to be accomplished***: * ***** • *Minor*: progressive improvement and customisation of the dashboards (autonomy in exploring data) [***8.6***] • *Major*: developing a clinical governance support system (extract value from the digital data) [***9.2***] • *Major*: correlating clinical and administrative data (further improvement of the appropriateness of the treatment) [***8.9***]	• *In my mind we have to switch from a mine to a bank. From raw data to be reworked by technicians to safe "on-the-shelf" data, directly accessible by businessmen* **—CEO** • *Our CEO is a data-fanatic. Last Christmas he phoned me complaining that he couldn't access the system…* **—CIO** • *To finish this project, we had to know each process like the back of our hand* **—CIO** • *Without having to ask for the help of ICT department every 5 minutes, users achieve autonomy, and better mine data* **—CFO** • *While the rest of H_{13} continued to follow the old way of doing things, here in the main facility we were experimenting the solution with a set of power-users* **—CIO** • *Without an adequate training nothing would have worked* **—CEO** • *The next step is an extension to clinical domain: the real value is there* **—CEO** • *The more you connect, the more digital data you can exploit to support decisions. The more you use digital data to support decisions, the more you need to connect the underlying resources producing these digital data. It's a sort of virtuous cycle than never ends* **—CIO**

* *Each statement in the table has been rated on a 10 points Likert scale in order to measure its importance (0 = not important; 10 highly important); the number in the squared brackets indicates the average importance provided by the informant in the last round of interviews; the table presents only the statements that have achieved an average importance rate higher than 7.0*
** *According the CIO, the problems indicated with "Major" risked to compromise the adoption; the problems indicated with "Minor" do not constituted great threats from this viewpoint*
*** *For each phase, the CIO has indicated its main impact (ER = exploratory; EI = exploitatory) and its grade of innovativeness (RI = radical; II = incremental; DI = disruptive)*
**** *Only the main approaches adopted to ambidextrously balance exploratory and exploitatory activities are reported in the table; temporal differentiation means that the hospital switches between exploration and exploitation over time; domain differentiation means that each unit specialises in exploratory or exploitatory activities in particular domain while the hospital balances these activities across domains; organisational differentiation means that exploration and exploitation occur simultaneously but are situated within distinct hospital units (Lavie et al., 2010); heuristic-based integration means that exploration and exploitation are integrated through the usage of a portfolio of deliberately small set of articulated and often informal rules-of-thumb (Eisenhardt et al., 2010)*
***** *According the CIO, the next steps indicated with "Major" had to be accomplished as soon as possible; the ones indicated with "Minor" were subject to the presence of further budgets for digital transformation*

Table 18. Main findings of the interviews performed on H_{13}