Master thesis

Platforms in healthcare: A qualitative multiple case study to explore how to achieve successful platforms for information, integration and innovation

Marit J. M. Kamphuis | **22-06-2021**

University of Twente
MSc Business Administration
Digital business
Faculty of Behavioural, Management and Social sciences

1st supervisor: ir. R. Siebelink PDEng (Remco)
2nd supervisor: dr.ir. E. Hofman (Erwin)

M&I/Partners
Rutger Leer - Principal consultant

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List of abbreviations

API = Application Programming Interface
EHR = Electronic Health Record
FHIR = Fast Healthcare Interoperability Resources
HCIM = Health and Care Information Model
HIS = Health Information System
NEP = National Exchange Point
PPC = Patient-Centred Care
PHE = Personal Health Environment
RHIO = Regional Health Information Organisation
SDK = Software Development Kit
SaaS = Software-as-a-Service
VBHC = Value-Based Healthcare
XDS = Cross-Enterprise Document Sharing

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Introduction

Healthcare is increasingly provided by collaborating healthcare organisations, healthcare providers and patients (Karam et al., 2018; Rudin et al., 2014). This increase in collaborations is largely related to the reorganization of care by the incorporation of new and effective models of care delivery, like Value-Based Healthcare (VBHC) and Patient-Centred Care (PCC)(Kitson et al., 2013; Porter, 2010; Porter & Lee, 2013). For healthcare organisations to work together, good coordination and information exchange is essential for patient safety and continuity and quality of care. At this moment, many technological and organisational barriers not only hamper these preconditions for proper collaboration but also the possibility to improve overall healthcare delivery (Porter, 2010; Vest et al., 2011).

In the Netherlands, the systems responsible for the exchange of health information, or in short, Health Information Systems (HISs), are often isolated within hospitals, physician practices and pharmacies (RSO Nederland, 2019). This fragmentation results in siloed information creation and storage. Mutual data exchange from these data silos is currently only possible to a limited extent. In combination with the increasing number of handoffs of patients among providers, the chance of failing to share important information increases (Vest & Gamm, 2010). This may result in the use of redundant healthcare services, but also serious patient safety and quality issues. Growing evidence shows that improved exchange of patient data has the potential to reduce these problems, translating into a decrease in mortality and costs (Miller & Tucker, 2014). Especially the reduction of costs is a relevant necessity for the Netherlands since the Netherlands is among the countries with the highest health expenditure as a percentage of the Gross Domestic Product (GDP)(CBS, 2019; Kroneman et al., 2016). Moreover, Dutch health expenditure is increasing every single year due to economic growth, technological advances, population growth and ageing.

Since different organisations in healthcare use different systems, infrastructures and standards, Dutch healthcare organisations have to create a complex landscape of application networks and infrastructures to be able to collaborate with other parties (RSO Nederland, 2019). Nowadays, multiple organisations exist which help healthcare organisations to facilitate this process. Besides the emergence of Regional Health Information Organisations (RHIOs), which are provider-led, non-profit associations that facilitate information exchange and innovation within a region, multiple private vendors started to offer "healthcare platforms", available for the entire Dutch healthcare sector (Fontaine et al., 2010; Jha et al., 2008; Vest & Gamm, 2010). In contrast to RHIOs, these private vendors recruit members based on economic incentives. They generate profits without having to meet the requirements for undertaking truly difficult tasks, like the support of smaller organisations that cannot finance necessary but expensive ICT solutions in order to realize universal connectivity in a region. As a result, the healthcare platforms from private vendors have the potential to grow at a much higher rate than RHIOs.

Three core functions of the newly emerging healthcare platforms can be distinguished (Fürstenau et al., 2019). The first and most important function is the exchange of information. The healthcare platforms facilitate information exchange by retrieving, translating and sharing medical data from various healthcare providers. They comply with existing trust frameworks, laws and regulations (Informatieberaad Zorg, 2019; KPMG, 2019). Among other things, this means that the platform verifies the access rights and the patient's consent before any information is released. The availability of patient information for healthcare providers makes it possible to enable data-driven medicine as treatments can be adjusted based on the needs of the patient (Rudin et al., 2014). Besides, the availability of information for the patients themselves enables their involvement in and control over their care pathway. The second core function of healthcare platforms is service integration in which platforms enable collaboration between providers and patients by offering digital support of healthcare processes. In this way, continuity of care can be improved and joint care pathways can be realized. A third, final function is service innovation. Most healthcare platforms can connect third-party applications to their platform, which brings possibilities to add functionalities and innovate healthcare processes at a fast pace.

In short, platforms have the potential to address two main problems in healthcare. A healthcare platform's ability to make previously unavailable, but critically important health information available is a necessary first step to address the current fragmentation of patient care across providers. Besides addressing the fragmentation of healthcare services, platforms can also tackle the current lack of innovation (Fürstenau et al., 2019). The platforms develop shared patient information repositories, enable data and process integration, and facilitate the interoperability of systems. One step further, they

facilitate innovation ecosystems, building on the collection, integration and analysis of patient data (Adner & Kapoor, 2010). In summary, for healthcare organisations, the connection to a healthcare platform shows great promise for improving the quality, safety and efficiency of healthcare within their organisation (Fontaine et al., 2010; Jha et al., 2008).

However, the concept of platforms in healthcare is relatively new and unknown. Only first efforts were observed to implement and scale digital platforms in healthcare (Furstenau & Auschra, 2016). While Apple Health and Google Fit slowly start to appear in the industry, examples of platforms that affect the everyday, regular healthcare processes are still rare. According to Google, who shut down its healthcare platform in 2011, many companies are unable to find a way to translate limited usage into widespread adoption in the daily health routines of millions of people. Furthermore, the attempts of Google′s and Apple′s healthcare platforms can still largely be described as closed as they excluded many parties from using and contributing to the platform (Eisenmann et al., 2009).

In general, platforms bring together producers and consumers in high-value exchanges. Their main assets are information and interactions, which are also the sources for their competitive advantage and the value they create (Van Alstyne et al., 2016a). Network effects are central in platform strategy as they generate increasing value for all connected participants. As a result of these effects, platforms can cause enormous growth which can abruptly upend their industries (de Reuver et al., 2018). Operating system platforms, like Android and iOS, have transformed the mobile telecommunications industry; payment platforms, like PayPal and Apple Pay, have disrupted the financial industry; and peer-to-peer digital platforms, such as Uber and Airbnb, have created so-called sharing economies. Platforms have transformed almost every industry nowadays and as a result, the competition within these industries is shifting toward platform-centric ecosystems. Some researchers expect that firms that fail to create platforms or are unable to learn the new rules of platform strategy, will not succeed to compete for long (Van Alstyne et al., 2016a, 2016b).

As a result of the disruptive impact of platforms, platforms receive increasing attention from researchers who seek to understand the platform logic (Tiwana et al., 2010). Besides, a lot of new research challenges arise as a result of the exponentially growing scale of platform innovation, the increasing complexity of platform architectures and the spread of digital platforms to many different industries (de Reuver et al., 2018). The literature on platform strategies is extensive, but the current literature on multi-sided platforms falls short in addressing the specific characteristics of strongly regulated and complex industries such as healthcare.

Conducting a qualitative multiple case study on healthcare platforms can help to define the proper scoping of platform concepts as the methodology makes it possible to explore and describe phenomena within their contexts (Baxter & Jack, 2008; de Reuver et al., 2018). It is unclear whether platforms in healthcare can exist in the same way as platforms in other industries. Some factors are distinct for the healthcare industry and it is valuable to know how healthcare platform deal with these factors to obtain and maintain a profitable platform business model. Compared to other industries, the progress of digitalization is much slower in the healthcare sector (Stegemann & Gersch, 2021). Implementation rates of ICT-based solutions in healthcare fall short in many major countries in the U.S. and Europe (Furstenau & Auschra, 2016). Reasons include the necessary regulation, the presumption of market failure, the complex systems of care and treatment processes, the variety of stakeholders and the lack of interoperability. In the Dutch setting, the government is interfering by drawing up laws and providing subsidies (VWS, 2020). For example, a new law will be introduced which requires that information exchange between healthcare providers must be done electronically (Rijkoverheid, 2020). The government has also introduced incentive schemes to stimulate the digitization of information exchange. Besides, all kinds of national initiatives have been set up to standardize increasingly more elements in health information exchange and to prevent vendor lock-in (Nictiz, 2020).

The literature has produced an understanding of how and why implementing and scaling IT-based solutions in healthcare is difficult, yet it says relatively little about the particular success factors and challenges in platform-based settings (Furstenau & Auschra, 2016; Fürstenau et al., 2019; Yaraghi et al., 2015). This study focuses on the core functions of healthcare platforms, which can be referred to as the three I's: Information, Integration and Innovation. The novelty of this study lies in the inclusion of very recent and promising forms of service delivery in healthcare, enabled by the growing availability of easily accessible healthcare Application Programming Interfaces (APIs). The software engineering institute (2003) defines an API as "a technology that facilitates the exchange of data between two or

more different software applications". APIs are often pieces of code that allow applications to interact with each other and refer to software interfaces that define the service that one software element provides to other software elements.

In summary, within the research, the goal is to create insight into the way existing Dutch healthcare platform companies use platform business models and deal with the distinctive characteristics of the Dutch healthcare sector. The research question is therefore formulated as follows:

"How to achieve successful platforms for information, integration and innovation in the specific context of the Dutch healthcare sector?"

By distinguishing the success factors of every case about the way they facilitate information exchange, service integration and service innovation, the potential of these platforms to improve or even transform healthcare in the future will be explored. Furthermore, by designing a model, the explanation of platforms in healthcare and relevant data-to-theory connections can be supported.

The goal of the research is to fill a part of the gap in the literature on healthcare platforms and their role in information exchange, service integration and service innovation. The results of this research are especially relevant for the companies with platform business models in healthcare since it may help them to be successful. However, the success of healthcare platforms may be just as important for the other stakeholders in healthcare since healthcare platforms have the potential to support healthcare organisations to exchange information and integrate and innovate their healthcare processes in a cost-effective way.

To be able to properly answer the research question, the following sub-questions are answered through a literature review:

- What are the different types of platform business models and ecosystems?
- What are the challenges for platforms?
- What are the design aspects of platforms?
- What are the strategies of platforms?
- What are the core functions of platforms in the healthcare sector?

The following sub-questions are answered through the case study research:

- What are the success factors for Dutch healthcare platforms to enable information exchange?
- What are the success factors for Dutch healthcare platforms to enable service integration?
- What are the success factors for Dutch healthcare platforms to enable service innovation?

Theoretical framework

The platform phenomenon has resulted in an increasing amount of academic research on platform competition (Armstrong, 2006; Eisenmann et al., 2006; Hagiu & Wright, 2015; Rochet & Tirole, 2003), platform leadership and innovation (Boudreau, 2010; Gawer, 2014; Gawer & Cusumano, 2014) and platform ecosystems (de Vasconcelos Gomes et al., 2018; Gawer, 2020; Jacobides et al., 2018; Parker et al., 2016). Besides, several platform typologies exist in the literature (Evans & Gawer, 2016; Gawer & Cusumano, 2014). In this theoretical framework, the platform business model and its characteristics are discussed first. Thereafter, different types of platforms and ecosystems are clarified. Finally, different platform challenges, design aspects and strategies are discussed.

The platform business model

Platforms have been around for years (Van Alstyne et al., 2016a). Malls link consumers and merchants and newspapers connect subscribers and advertisers. The fundamental change that has occurred in the current century is that Information Technology (IT) has profoundly reduced the need to own physical infrastructure and assets. IT makes the building and scaling up of platforms simpler and cheaper. It also allows nearly frictionless participation that strengthens network effects and enhances the ability to capture, analyse and exchange big amounts of data that increase the platform′s value to all users. Three transformative technologies can be distinguished for the rise of platforms, namely: cloud, social and mobile (Bonchek & Choudary, 2013). The cloud enables a global infrastructure for production, allowing anyone to create content and applications for a global audience. Social networks enable people to connect globally and maintain their identity online and mobiles allow connection to this global infrastructure anytime and anywhere.

Over the past decade, enterprises that use the power of platform business models have grown exponentially in size and scale (Evans & Gawer, 2016; Gawer & Cusumano, 2014). The use of platforms started in the domain of, among others, social media, travelling, books and music, but has in the meantime also made entry into the transportation, banking and healthcare industry. The success of platforms is realized through the digitalization of products, services and businesses processes, where platform companies contribute to the economy by enabling increased productivity. They do this through the efficient matching of different user groups that can profit from each other or by supporting more efficient asset utilization with the so-called ″sharing economy″. Platforms have also shown to be important sources of innovation, as nine U.S. platforms were awarded over eleven thousand patents in 2014 (Evans & Gawer, 2016).

Conventional ″pipeline″ businesses have dominated industries for decades. They create value by controlling a linear series of activities, also called the classic value-chain model. A firm can either be a pipeline or a platform but it can also be both. However, when platforms enter a marketplace with solely pipeline businesses, the platform almost always wins (Van Alstyne et al., 2016a). A lot of pipeline giants are trying to incorporate platforms into their models. A pipeline business differs from a platform in three aspects. Firstly, pipeline businesses control resources and platforms orchestrate resources. Pipeline businesses take advantage by controlling a limited amount of scarce and valuable assets, while the platform′s key asset is its whole network of users and the resources these users own and contribute. Secondly, pipeline businesses create value by optimizing their internal processes, while platforms create value by facilitating interactions between external user groups in which they avoid most of the variable production costs. Thirdly, pipelines focus on customer value while platforms focus on ecosystem value.

Online platforms have now disrupted complete industries, like Uber for the transportation industry and Netflix for the television industry (de Reuver et al., 2018). Platforms also have the potential to equally disrupt other industries, which may also become the case for the healthcare industry that is central in this study. Besides the many advantages, companies with platform business models also bring concerns. A platform has the ability to dominate a complete market and undermine competition, which is becoming the case in companies like Google, Amazon, Facebook and Apple (Moore & Tambini, 2018). Other concerns include the ease in which they can avoid tax and insurance obligations and how they classify users as independent contractors to reduce wages (Evans & Gawer, 2016).

Different authors have constructed typologies of the different existing platform types (Evans, 2003; Evans & Gawer, 2016; Gawer & Cusumano, 2014). The most relevant typologies for the classification and understanding of healthcare platforms will be discussed in the next section.

Platform typology

To provide clarity, this study will use the terms "transaction platform" and "innovation platform" (Cusumano et al., 2019; Evans & Gawer, 2016; Gawer, 2020; Koskinen et al., 2019). In literature, a division between two theoretical perspectives can be distinguished (Gawer, 2014). One is inspired by economic theory and the other by engineering design. In this study, transaction platforms are based on the economic perspective that focuses on how platforms as two-sided or multi-sided markets mediate transactions across different customer groups and how network effects fuel platform competition (Evans, 2003; Rochet & Tirole, 2003; Rysman, 2009). Innovation platforms, on the other hand, are based on the engineering design perspective that views platforms as technological designs that help firms generate modular product innovation (Baldwin & Woodard, 2009; Gawer, 2011). The two theories have focused on the different directional forces platforms respond to. While the economic perspective has yielded insights on platform competition between markets, the engineering design perspective has focused on platform innovation within ecosystems.

Both transaction and innovation platforms can be characterized as multi-sided platforms. A multi-sided platform facilitates value-creating interactions between two or more distinct groups of users (Evans & Schmalensee, 2005; Hagiu & Wright, 2015). According to Tiwana (2013), a platform is by definition at least two-sided where one-sided platforms cannot be considered as true platforms at all. Instead, they are products or services often mislabeled as platforms. According to Evans (2003), there are three conditions under which a multi-sided platform may emerge, namely that (1) there are distinct groups of customers; (2) a member of one group benefits from the connection with one or more members of another group; and (3) an intermediary can facilitate the connection and coordination between these groups more efficiently than direct relationships between the members of the group. The distinct groups of users are also called the different "sides" of the platform. The different sides have an affiliation with the platform and the platform facilitates direct interaction or transaction between these different sides (see figure 1).

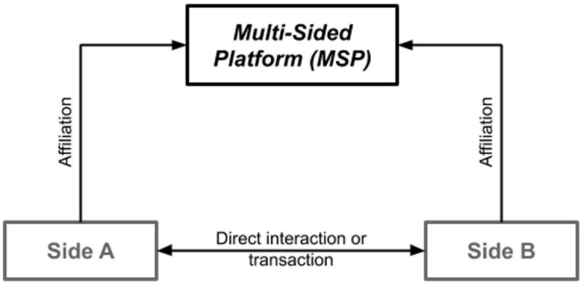

Figure 1: Multi-sided platform model

In the literature, another type of platform, namely the internal, product platform, is also often mentioned. This type of platform is used within companies to efficiently develop and produce a family of products. It has similar characteristics as transaction and innovation platforms, like modular design and associated design rules (Gawer, 2014). However, the healthcare platforms that are explored in this study can be characterized as either a transaction platform or an innovation platform, or as both. The internal, product platforms are therefore outside the scope of this study.

Network effects

In the existing literature, multi-sided platforms are often associated with network effects (Armstrong, 2006; Evans, 2003; Gawer & Cusumano, 2014; Rochet & Tirole, 2003; Rysman, 2009). The literature on network effects typically focuses on the adoption by users and optimal network size as the platform's value to their users largely depends on the number of users on the network's other side and, possibly, also on the network's same side. Two types of network effects may arise, which can either be positive or negative.

The first type is the same-side or direct network effect, in which an increasing number of users on one side of the network is either more or less valuable for users on the same side (Eisenmann et al., 2006). For example, when a side includes developers, the direct network effects are negative, because more developers mean more competition for the other developers. Contrarily, when a side includes users of video game consoles, the direct network effects are positive, because new users will find it easier to trade games with friends or find partners for online play.

The second type is the cross-side or indirect network effect, in which increasing the number of users on one side of the network makes it typically more valuable for users on the other side (Eisenmann et al., 2006). For example, when one side of the platform creates demand and the other side creates supply, the sides can take advantage of each other. This means that the indirect network effects are positive. See also figure 2 for a graphical representation of direct and indirect network effects.

Network effects are essential for platform companies (Gawer & Cusumano, 2014). The more value a side creates in the form of innovation by complementors or just in the form of users that serve as supply or demand, the stronger the network effects. This creates a cumulative advantage. As their installed base grows, they become harder to beat by competitors or new entrants, with the growing number of users or complementors acting like a barrier to entry.

Besides the size of the installed base and the availability of complementary goods, the value of a platform characterized by network effects can also be determined by the standalone functionality and performance of the platform (Gawer, 2011). A platform company can increase its technology′s functionality and performance through its own R&D investments or by attracting the development contributions of parties external to the company. Although it is often not the best technology that achieves dominance, a technology′s functionality and the rate at which it is improved still play crucial roles in its adoption. Research shows that wholly open technologies are more likely to be improved over time through the development efforts of external parties but are also more likely to become fragmented. On the other hand, a platform that protects and controls its technology has the ability to protect the integrity of the technology and prevent the fragmentation of the platform.

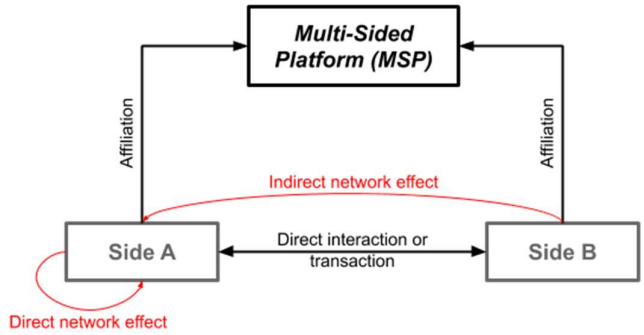

Figure 2: Direct and indirect network effects (on side A)

Transaction platforms

One of the ways in which platforms can create value is by facilitating transactions between different types of individuals and organisations that would otherwise have difficulty finding each other (Cusumano et al., 2019; Evans & Gawer, 2016; Gawer, 2011, 2020; Koskinen et al., 2019). In literature, these kinds of platforms are defined as transaction platforms. Obvious examples of transaction platforms are Uber, Google Search and Amazon Marketplace, which are used by billions of people every day.

A transaction platform corresponds to a supply-chain platform as defined by Gawer and Cusumano (2014). Multi-sided markets where the role of the platform is purely to facilitate exchange or trade, without the possibility for third parties to innovate, belong to this supply-chain category. Transaction platforms are often intermediaries or online marketplaces that make it possible for people and organisations to share information or to buy, sell, or access a variety of products and services (Cusumano et al., 2019). The more users, functionalities and digital content or services that are available through the platform, the more valuable it becomes. It is mostly the digital technology and scale that make these platforms unique and powerful.

Transaction platforms create and deliver value by facilitating the buying and selling of products and services or by facilitating other interactions, such as enabling users to create and share content (Cusumano et al., 2019). The firms that own this type of platform primarily capture value by collecting transaction fees, by charging for advertising, or both. The literature on transaction platforms usually takes an economic perspective and focuses on the way platforms as markets mediate transactions across different user groups (Gawer, 2014). It offers a demand-side view of platform competition, as understood as the competition between platforms and not within platform ecosystems. It also takes into consideration how network effects fuel this platform competition.

Innovation platforms

The second way in which platforms can create value corresponds to innovation platforms (Evans & Gawer, 2016; Koskinen et al., 2019). These types of platforms correspond with industry platforms, defined by Gawer and Cusumano (2014), and with digital platforms, which are defined as *"an extensible codebase to which complementary third-party applications can be added"* (Boudreau, 2010; de Reuver et al., 2018; Tiwana et al., 2010). By "complementary", the innovations are meant that add functionality or access to assets that make the platform increasingly useful (Cusumano et al., 2019). For an innovation platform to perform the industry-wide role and convince complementors and users to adopt the platform as their own, the platform must (1) perform a function that is essential to a broader technological system and (2) solve a business problem for many firms and users in the industry (Gawer & Cusumano, 2014). The network effects come from the increasing number or value of the complements. The more complements or the higher quality of the complements, the more attractive the platform becomes to users, as well as other potential market actors such as advertisers and investors. Examples are Apple's iOS with its iPhone apps and Mozilla's Firefox browser with its Firefox extensions.

Innovation platforms are similar to product and supply-chain platforms in that they provide a foundation of reusable common components or technologies (Gawer & Cusumano, 2014). The potential benefit of the reuse of technologies is the ability to produce a large number of different services with limited resources. It offers the possibility to save fixed costs and to be flexible in product feature design. As a result, the platform companies can meet diverse customer requirements, business needs and technical advancements while maintaining economies of scale and scope. The difference between innovation platforms and product and supply-chain platforms is that the foundation is "open" to outside firms (Gawer & Cusumano, 2014). The degree of openness can vary in several dimensions. Examples of these dimensions are the costs of access and the level of access to information on interfaces to link to the platform or utilize its capabilities. In contrast to the literature on transaction platforms, the literature on innovation platforms usually takes more of an engineering design perspective (Gawer, 2014). From this perspective, a platform consists of technological building blocks that are used as a foundation on top of which a large number of innovators can develop complementary services or products. Innovation platforms have been found to operate within even larger networks of firms that are not necessarily linked through buyer-supplier relationships, also known as "innovation ecosystems".

Integration platforms

Platforms can also be both a transaction platform and an innovation platform. These platforms are sometimes called integration platforms or hybrid companies (Evans & Gawer, 2016; Gawer, 2020). Platforms can become hybrids when they choose to add a new side, for example, third-party developers, by opening one or more APIs and by releasing corresponding Software Development Kits (SDKs) and reference documentation. The main reason transaction platforms add an innovation side is that more apps or features will make the platform more compelling to users. It may also create additional monetization opportunities. Uber, for example, started to offer a free API which enabled app developers to allow users to request an Uber ride from within their own apps.

Platform ecosystems

In general, the term "ecosystem" refers to a group of interacting firms that depend on each other's activities (Adner & Kapoor, 2010; Jacobides et al., 2018). Three streams of ecosystem research can be identified. The "business ecosystem" stream focuses on a firm and its environment. It focuses on an

individual firm and views the ecosystem as a community of organisations and individuals that impact the enterprise itself and its customers and suppliers. The "innovation ecosystem" stream focuses on a particular innovation and the set of components (upstream) and complements (downstream) that support it. It views the ecosystem as the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. Finally, the "platform ecosystem" stream considers how actors organize around a platform. Platform ecosystems are seen as semi-regulated marketplaces that foster entrepreneurial action under the coordination and direction of the platform sponsor, or as multisided markets enabling transactions among distinct groups of users (Cennamo & Santalo, 2013).

The terms "business ecosystems", "innovation ecosystems" and "platform ecosystems" have been used in very polysemic and sometimes competing ways (de Vasconcelos Gomes et al., 2018). Building on Gawer's (2014) ideas, which indicate that the literature on platforms is divided into the technological, innovation perspective and the economics, competition perspective. Similarly, the ecosystem construct can be divided into two perspectives of management. The business ecosystem mainly relates to value capture, more related to the competitive power side and similar to multi-sided markets and the innovation ecosystem mainly relates to value creation, more related to the innovation side.

Multi-sided market

In the case of transaction platforms, the platform can be seen as a multisided market that enables transactions among distinct groups of users. Multi-sided markets can be characterized by two or more distinct groups of users that interact through an intermediary or platform in which the decisions of one group affect the outcomes of the other group (Armstrong, 2006; Eisenmann et al., 2006; Rysman, 2009). Also, the benefits of a group from joining the platform depends on the size of the other group that joins the platform. The literature on multi-sided markets focuses on the actions of the market intermediary. Especially when there is some kind of interdependence between groups of users that the intermediary serves, the choices by market intermediaries, particularly pricing, are well explored.

Transaction platforms are not necessarily in themselves ecosystems as they do not require the creation of a specific structure of relationships and alignment to create value (Jacobides et al., 2018). They, for example, do not have to lock application developers in their platform by allowing them to connect via APIs in ways that are specific to their device. Instead, they often only require generic complementarity. For example, dating bars and websites are two-sided markets as they facilitate transactions between two distinct groups of users (Gawer & Cusumano, 2014). There is, however, no need for complementary innovations facilitated by the existence of the platform. There are exceptions to this as some platforms, to be able to strengthen their position, may choose to require some complementors.

Platform-based ecosystem

For innovation platforms, the platform ecosystem can not only be seen as a multi-sided market, but also as an innovation ecosystem. The ecosystem consists of the platform itself plus all providers of complements that make the platform more valuable to consumers (Gawer, 2014; McIntyre & Srinivasan, 2017). From a technical view, the ecosystem can be defined as *"the collection of complements (apps) to the platform, mostly supplied by third-party developers"* (de Reuver et al., 2018; Tiwana et al., 2010). The complementors can connect to the central platform via shared or open-source technologies or technical standards. In the case of IT-related platforms, these connections take the form of programming interfaces or SDKs. When the complementors are connected, they can not only generate complementary innovation but also gain access, directly or indirectly, to the platform's customers.

According to Van Alstyne et al. (2016a), platforms all have an ecosystem with the same basic structure, comprising four types of players (see figure 3). The owners of platforms control their intellectual property and governance, providers serve as the platforms' interfaces with users, producers create the platform's offerings and consumers use those offerings. The players in an ecosystem fulfil the four main roles but they can shift rapidly from one role to another. A player deciding to take a new role can be either accretive or depletive. Consumers and producers can swap roles in ways that generate value for the platform, like riders and drivers for Uber and travellers and hosts for Airbnb. In contrast,

providers can also be depletive of a platform when they decide to compete with the platform. Understanding the relationships both within and outside the ecosystem is central to platform strategy.

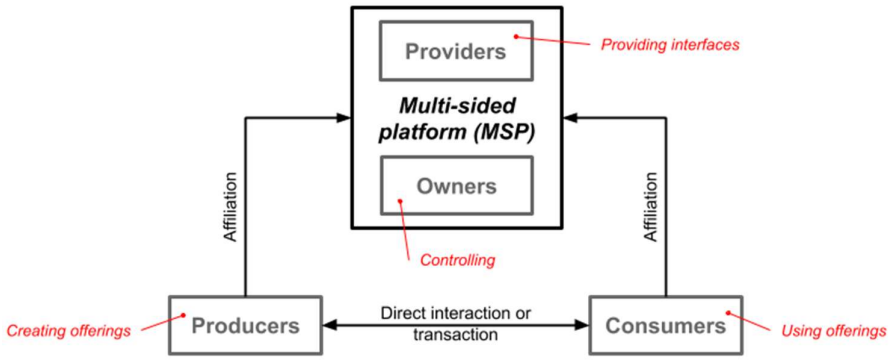

Figure 3: Basic structure of a platform ecosystem, based on Van Alstyne et al. (2016a)

As discussed in the previous sections, multisided platforms can be characterized as transaction or innovation platforms. Transaction platforms are usually seen as multisided markets with a focus on competition using indirect and direct network effects. Innovation platforms are usually seen as technological architectures with a focus on developing innovation ecosystems. Table 1 in appendix I can be consulted for an overview of the results from the literature review on platform and ecosystem typologies. Besides, a more extensive summary of the differences between transaction and innovation platforms can be found in table 1 (Cusumano et al., 2019; Gawer, 2014; Koskinen et al., 2019).

Table 1: Definitions and characteristics of transaction and innovation platforms

	Transaction platform	**Innovation platform**
Definitions	Supply-chain platform, transaction platform	Industry platform, innovation platform, digital platform
Purpose	Matches users or user groups, the value for a user increases with the number of users in a user group	An extensible codebase as a core that enables the adding of third party module
Target group	Participants to a transaction	Application developers
Perspective	Demand perspective (mediates among users)	Supply perspective (mediates among innovators)
Key governance issues	Attracting users from the relevant group (indirect/direct)	Relationship between developers and platform owners
Theories	Platforms as multisided markets, focus on competition using indirect and direct network effects	Platforms as technological architectures, focus on developing innovation ecosystems
Value creation	Facilitating interactions or facilitating buying and selling of goods and services	Facilitating development of new complementary product and services
Value capture	Collecting transaction fees and/or charging for advertising	Directly selling or renting a product or monetization by selling advertisements or other services

Platform challenges

To successfully incorporate a platform business model, platform companies are likely to face multiple challenges (Evans, 2003; Evans & Schmalensee, 2005; Van Alstyne et al., 2016b). To take advantage of network effects, it is important to overcome the critical mass challenge and to take the correct timing in the launching stage of the platform (Evans & Schmalensee, 2010). If the platform survives this stage and manages to benefit from network effects, new challenges may arise (Armstrong, 2006; Rochet & Tirole, 2003). Especially when the platform has to deal with competition from other platform companies, multi-homing and envelopment are likely to occur.

Critical mass challenge

The critical mass challenge means that platforms must get a sufficient number of users of both sides on board to launch successfully (Evans & Schmalensee, 2010). Platforms rely on both direct and indirect network effects to attract users. For direct network effects, the level of participation affects the quality of the products or services it offers to users. The main problem is that when the quality is too low, participation decreases, which reduces quality further, and so forth. For indirect network effects, participation by each side of the platform affects the quality experienced by the other groups (Evans & Schmalensee, 2010). Participation levels below the critical mass will result in a similar downward spiral. This challenge is also called the chicken-and-egg problem. The demand on each side is dependent on the demand on the other side, regardless of the price (Evans, 2003). Several strategies can help to increase participation on the sides where the critical mass is not yet reached. Platforms need to empathize on building network effects as this is the core mechanism by which platforms create value at scale. Emphasizing revenue generation rather than attracting a critical mass of participants in the first place, is one of the biggest reason platforms fail (Van Alstyne et al., 2016b).

Timing

Timing is crucial for platforms (Cusumano et al., 2019; Yoffie et al., 2019). Entering a market late can be fatal, especially when other platforms have already connected with most of the actors in the market. Being early is thus preferable but no guarantee of success. The smartphone market is a classic example of how great products may still lead to failure in a platform market when entry is too late. In 2017, despite billions of dollars of investments over a decade, Microsoft's Windows Phone failed. It missed the platform window and never recovered. Platforms and their ecosystems take time to build. This is especially true for innovation platforms, where platforms need developers to innovate and a lot of consumers that attract those developers and use their innovations. It is essential that market entries carefully investigate what strategies and investments might disrupt the existing platform leaders.

Multi-homing

When users find it beneficial and efficient to use several competing platforms, this situation has been called "multi-homing" (Evans, 2003). In several contexts, multiple platforms coexist, because platform differentiation is possible, fixed costs relative to market size are low, costs of adopting multiple platforms are not too high, or network externalities do not have enough strength (Cennamo & Santalo, 2013). When multi-homing is not possible, for example when switching from one platform to another is difficult or costly, network effects are reinforced (Eisenmann et al., 2006; Gawer & Cusumano, 2014). In general, there are three cases to consider, namely 1) all sides single-home, 2) one or more side(s) single-home(s) while the other(s) multi-home(s) and 3) all sides multi-home (Armstrong, 2006). In the first case, there is perfect competition in which users have no preference for one platform over another except for the number of users on the other side and lower prices. The third case is uncommon in multi-sided markets because if the users of one group join all platforms, there is no need for the other group to join more than one platform. The second case, however, resembles a lot of markets. Armstrong (2006) terms this kind of platforms "competitive bottlenecks". A platform has monopoly power over its multi-homing side, because of the exclusive access it can provide to its single-homing users.

Envelopment

Although a platform may do a great job addressing critical mass and multi-homing challenges, the platform still has the possibility to face a third challenge, namely envelopment (Eisenmann et al., 2006). The platform may be enveloped by a similar platform, starting to offer significantly better services and entering the same market. Gawer (2014) describes platform envelopment as a bundling strategy through which platforms attack their target by extending their functionalities. They can do this through leveraging shared user relationships, or demand-side economies of scope, as well as common components, or supply-side economies of scope. Overlapping user bases can make it easy and attractive for one platform to swallow the network of another. Real damage emerges when a new competitor offers another platform's functionality as part of their multiplatform bundle, especially when this results in the competitor's bundle delivering more functionality at a lower total price.

Design aspects and strategies

Platforms need to design their platform in a certain way to successfully make use of their strategies and to overcome challenges (Evans, 2003; Evans & Schmalensee, 2005; Van Alstyne et al., 2016b). According to Bonchek and Choudary (2013), the success of a platform strategy is determined by three factors. These factors are the way in which the platform attracts users, the ease with which others can plug into the platform and the way in which the platform fosters exchange and co-creation of value. Successful platforms achieve these goals by incorporating one or more of the following building blocks: the magnet, the toolbox and the matchmaker. Transaction platforms often focus more on the magnet and matchmaker role, while innovation platforms emphasise more on building the toolbox. Each of the building blocks consists of relevant strategies, like pricing and governance strategies. Table 2 shows an overview of the literature.

Table 2: Results from literature review on platform design aspects and strategies

	Design aspects and strategies													
	The magnet					**The toolbox**				**The matchmaker**				
	Direct network effects	Indirect network effects	Pricing strategies	Winner-takes-all strategy	Trust	Platform openness	Platform boundary resources	Platform transparacy	Platform accessibility	Differentiation	Process control	Input control & securing	Output control & monitoring	Governance structure
Armstrong, 2006	✓	✓	✓											
Benlian et al., 2015								✓	✓					
Bonchek & Choudary, 2013	✓	✓	✓		✓		✓	✓	✓					
Boudreau, 2010						✓		✓	✓		✓	✓	✓	✓
Cennamo & Santalo, 2013	✓	✓		✓						✓				
Cusumano, 2019	✓	✓	✓	✓	✓					✓				
de Reuver et al., 2018						✓	✓							
Eisenmann et al., 2006	✓	✓	✓	✓										✓
Eisenmann et al., 2009						✓			✓					✓
Evans, 2003	✓	✓	✓											
Evans & Schmalensee, 2005	✓	✓	✓							✓				
Evans & Schmalensee, 2010	✓	✓												
Gawer, 2014						✓	✓	✓	✓					✓
Gawer, 2020						✓	✓				✓	✓	✓	
Ghazawneh & Henfridsson, 2013							✓	✓	✓			✓		
Hein et al., 2016			✓		✓	✓	✓	✓	✓		✓	✓	✓	✓
Rochet & Tirole, 2003	✓	✓	✓											
Rysman, 2009	✓	✓	✓							✓				
Tiwana et al., 2010						✓					✓	✓	✓	✓
Van Alstyne et al., 2016b						✓			✓		✓	✓	✓	✓
Yoffie et al., 2019			✓		✓									

The magnet

It is not enough for platforms to only provide connections with their users (Bonchek & Choudary, 2013; Van Alstyne et al., 2016b). A platform needs to attract users of different sides to achieve critical mass. Transaction platforms typically need to attract both buyers and sellers, loaners and renters or providers of services and users of services (Gawer, 2020). Besides, innovation platforms need to attract both

developers and users. Platforms can distinguish themselves in the way they attract users by paying attention to their pricing, growth strategies and trust, among other things.

Pricing strategies

Pricing strategies can play a big role in overcoming platform challenges and it largely decides whether a platform becomes a success or not (Cusumano et al., 2019; Eisenmann et al., 2006; Evans, 2003; Evans & Schmalensee, 2005; Rysman, 2009; Yoffie et al., 2019). The pricing decision can therefore be considered as one of the key success factors of a platform company. As one of the most common mistakes of platforms is mispricing on one side of the market, getting the prices right and identifying which sides to subsidize remain the biggest challenges.

The pricing decision has been the subject of rigorous research (Rysman, 2009). In multi-sided markets, the pricing to one side of the market does not only depend on the demand and costs that those users bring because their participation affects the participation on the other sides and the profit that this brings. As a result, the effect of a lower price on one side, the so-called subsidy side, can have a much larger effect on multi-sided markets (Eisenmann et al., 2006). The low price not only attracts consumers on that side but also leads to higher prices or more participation on the other sides. Subsequently, this increased value increases the value of having consumers on the first side, which leads to an even bigger price decrease and quantity increase on this side. Platforms could, for example, set low prices to penetrate the market and grow the total number of users. The next step would be to leverage this installed base to make money on the other side of the market by charging developers of applications that access the platform to reach these potential customers. Moreover, providing low prices to one side of the market can help to solve the chicken-and-egg problem (Evans, 2003; Rysman, 2009; Yoffie et al., 2019). By encouraging the benefited group′s participation, the non-benefited group is also encouraged to participate as a result of network effects. If there are multiple competing market intermediaries, the participation of one side on the other has even more impact since it can discourage the use of competing, more expensive, platforms.

According to Armstrong (2006), three main factors determine the structure of prices that is offered to the different sides. The first factor is the relative size of the cross-group effects. If a user of one side has a large positive effect on each user of the other side, then the first group will be the focus target of platforms. Platforms may do this by offering lower prices to this group. The second factor is the fixed fees or per-transaction fee. The crucial difference between the two charging bases is that the indirect network effects are weaker when a platform charges per-transactions fees. The reason for this is that a fraction of the benefit of interacting with an extra user on the other side is decreased by the extra payment incurred. On the other hand, when a user only pays a platform in the event of a successful interaction, he does not need to worry about how well the platform deals with the other side. This means that, for a platform to attract one side of the market, it is not so important to first get the other side on board. The third factor is single-homing or multi-homing. In the case of competitive bottlenecks, the monopoly power leads to high prices being charged to the multi-homing side. However, to compete for the single-homing users, the high profits from the multi-homing side are reduced by offering lower prices to the single-homing side. Rochet and Tirole (2003) refer to the single-homing users as marquee buyers. These marquee buyers are certain customers that are extremely valuable to customers on the other side of the market. The existence of marquee buyers tends to reduce the price to all buyers and increase it to sellers. Besides, extremely loyal customers can influence the pricing structure in the same way. These users have, for example, long-term contracts or sunk-cost investments.

Winner-take-all strategy

As mentioned before, network effects result in consumers placing a higher value on platforms with a larger number of users. Because of the network dynamics, the literature generally predicts a ′winner-take-all′ outcome in which the platform with the largest number of users will eventually obtain almost all market share (Cennamo & Santalo, 2013). Winner-take-all strategies are therefore often aggressive ′get-big-fast′ strategies that have three main goals, namely: 1) to rapidly acquire and grow the platform′s total users; 2) to lock in those users and; 3) to undermine the ability of rival platforms to do the same. The likelihood of a winner-take-all-or-most outcome in a platform company will depend on the strength

of network effects, the difficulty of multi-homing, the lack of opportunities for competitor differentiation and niche competition and the strength of entry barriers (Cusumano et al., 2019; Eisenmann et al., 2006).

Two popular growth strategies identified by the winner-take-all literature are "apps market competition" and "apps exclusivity" (Cennamo & Santalo, 2013). Promoting competition among applications developers is one mechanism platforms use to make their systems more competitive and to enhance their overall competitive positions. Platforms can influence the degree of apps market competition in a variety of ways, including licensing policies, technical support for development programming and the use of 'soft power' inducements. Apps exclusivity, on the other hand, is the extent to which a platform's complementary applications are only developed for and sold on one platform. The primary objective of exclusivity is to provide users with high-quality applications they will be unable to obtain on other platforms. By securing a larger number of popular applications in exclusivity deals, platforms can outcompete rivals. The research of Cennamo and Santalo (2013) shows that both strategies have an independent, positive and significant effect on platform market share, suggesting that in isolation these two strategies have beneficial effects on platform performance. However, the research also shows that implementing both strategies at the same is detrimental for platform performance because of the conflicting incentives they imply for application providers and because the configuration of activities they jointly require can be incompatible.

Trust

One of the most common mistakes of platforms is the failure to develop trust with users and partners (Cusumano et al., 2019; Yoffie et al., 2019). Platforms become more attractive when they exude trustworthiness and when the perceived risk of their users is minimized (Hein et al., 2016). However, asking end-users or complementors to trust platforms, without history and any prior connections to the other side of a market, is not realistic (Van Alstyne et al., 2016a). Trust can be built through rating systems, payment mechanisms, or insurance. Platforms can, for example, add ratings to the applications they offer or offer tools that help users to report errors. Platforms can also build trust by adding instant messaging to the website, allowing buyers and sellers to interact directly and to build trust. Besides, online payment systems of platforms have shown to have a big effect on the trust of users (Cusumano et al., 2019). Alibaba, for example, launched its own online payment system based on an escrow model. This means that the money of a purchased item is kept in an escrow account and will only be released after the buyer received and inspected the item. It was important for Alibaba to use this model to respond to a culture where trust and security are an issue.

The toolbox

Innovation platforms, in contrast to transaction platforms, provide value to their sides' users by acting as a technological foundation upon which the users of one side can develop or grant access to new complementary innovations (Boudreau, 2010; Gawer, 2020; Ghazawneh & Henfridsson, 2013). Therefore, one side of innovation platforms will always consist of developers of complementary innovations. They are the platform's complementors or complementary partners. Innovation platforms usually provide a toolbox that makes it easy for others to plug into the platform (Bonchek & Choudary, 2013). Apple, for example, provides developers with software development tools, programming interfaces and technical resources to help software developers write software. The toolbox is related to platform openness, boundary resources, transparency and accessibility.

Platform openness

One important design rule for an effective innovation platform is that the interfaces around the platform should be sufficiently open to allow outside firms to plug in their complements as well as to innovate on these complements and to make money on their investment (Gawer & Cusumano, 2014). A platform is "open" to the extent that no restrictions are placed on participation or restrictions are applied uniformly to all potential platform participants, like requirements to conform with technical standards or pay licensing fees (Eisenmann et al., 2009). Research shows that granting greater levels of access to independent developers produces up to a fivefold acceleration in the rate of development (Boudreau, 2010). Different approaches to opening a system influence the rate of innovation differently. A trade-off needs to be made by the impact of opening on various aspects of innovation and technical progress,

like the improvement of individual components; the creation of extensions, add-ons and upgrades; the elimination of bugs and errors; and quality and cost improvements.

Platforms have to decide when to rely on third-party developers versus in-house units for platform components (Eisenmann et al., 2009). In general, platforms approach such "make-buy" choices in the same way as counterparts in traditional industries. The focus here is, however, on decisions about strategies that are distinctive to platform-mediated networks. Three sets of choices can be related to the extent to which platforms open or close the supply-side user role. First, platforms have to determine whether to extend backward compatibility to complements developed for past platform generations when they decide to upgrade the platform. Not providing backward compatibility closes the platform when it limits existing third-party developers to access new versions of the platform. Second, platforms must weigh the advantages of granting exclusive access rights to selected developers, as discussed earlier under winner-take-all strategies. Finally, platforms need to consider absorbing certain complements, previously supplied by third parties, into the core platform. Complement absorption can result in efficiency gains by users as well as economies of scope for the platform. Integrated designs may yield quality advantages through simplification of interfaces and may offer the opportunity to sell a more valuable bundle with a single marketing campaign.

In addition to vertical strategies related to the supply-side user role, horizontal strategies target a firm′s existing and future rivals (Eisenmann et al., 2009). These strategies are related to the extent to which the platform allows rival platform′s users to interact with its own users and the extent to which third parties are allowed to participate directly in the platform′s technical development. As mentioned before, the value of a platform partly depends on the functionality and performance of the platform itself. A wholly open technology may be produced, distributed and promoted by multiple parties, accelerating the growth of the platform′s installed base (Gawer, 2011). Competition among producers may decrease the price and improve the quality of the technology, making it more attractive to customers. Disadvantages may be free-rider problems, where an individual company′s efforts to promote the technology may result in benefits that are distributed among multiple companies. In contrast, if the platform itself is the primary beneficiary of its technology′s success, it has a much greater incentive to promote the technology and accelerate the growth of its installed base.

Platform boundary resources

Platform boundary resources are the software tools and regulations that serve as the interface for the relationship between the platform owner and the application developer (de Reuver et al., 2018; Gawer, 2020; Ghazawneh & Henfridsson, 2013). The openness of digital platforms does not merely relate to organisational arrangements like entrance and exit rules but also to the openness of technologies such as APIs and SDKs. The degree of openness is related to the extent to which platform boundary resources support complements (Eisenmann et al., 2006; Hein et al., 2016). The concept of open interfaces can be understood by the sense that the interface contains information that is accessible to complements and usable by them to build complementary innovation that is compatible with this interface (Gawer, 2014). By opening interfaces, platforms can access a potentially unlimited pool of external capabilities.

Boundary resources are crucial for platform owners to balance between stimulating external contributions and maintaining platform control. There are two drivers for boundary resources design. Resourcing is the process by which the scope and diversity of a platform are enhanced. Securing is the process by which the control of the platform is increased. Attention to both these drivers is important to develop a platform ecosystem. Throughout different stages of the evolution of an ecosystem, specialised constructs can be distinguished for the actions taken by stakeholders in third party development, namely: a) self-resourcing, which is the developers′ act of developing new boundary resources as a response to perceived limitations in existing boundary resources; b) diversity resourcing, relates to the action taken by a platform owner to diversify the platform in a way that stimulates new application areas; c) regulation-based securing, which is the platform owners′ act of exercising control over the platform through regulative measures; and d) sovereignty securing, which refers to actions taken by a platform owner to avoid envelopment.

Platform transparency

Platform transparency is defined as the extent to which third-party developers fully understand how to create and distribute third-party applications on a platform, as well as to comprehend and follow all platform-related governance decisions (Benlian et al., 2015; Hein et al., 2016). In other words, transparency is about the understanding of what is happening and why and refers to all aspects that refer to the platform′s information policies. A transparent platform can be recognized by the following indicators: 1) It offers features that allow developers to communicate and exchange with other developers; 2) The available documentation includes all relevant information for the development of applications, e.g. reference designs (Boudreau, 2010); and 3) It offers features to receive instant technical support from the platform.

Platform accessibility

Platform accessibility is defined as the degree to which a platform provides resources that allow developers to contribute to the platform by creating and distributing third-party applications without having to face platform-specific restrictions (Benlian et al., 2015; Hein et al., 2016). In other words, accessibility involves all aspects of how applications of third-party developers are constrained or supported on the platform. Platforms deal differently with the accessibility of the platform to outsiders (Boudreau, 2010). The liberalness with which the platform owner grants licenses can deviate from a policy of not licensing outsiders to licensing everyone (Boudreau, 2010). Platform owners can also choose to restrict the number of licensees or to restrict the licenses to the development of certain products for particular market niches. An accessible platform can be recognized by the following indicators: 1) The technical standards are easy to learn; 2) It offers helpful tools that make the development of applications easier; 3) It supports technical interoperability with other systems or platforms; 4) The scope of functionalities that is made available to developers (via APIs) is broad; 5) The technical performance of the platform supports the functioning of applications; 6) The initial costs for technical requirements (e.g., fees or hardware requirements) are not limiting the access to the platform.

The matchmaker

Platforms create value by making successful connections between users. The more users are connected to the platform, the higher the chance the platform can match supply and demand (Bonchek & Choudary, 2013). The number of users is thus important to increase the probability that a buyer or loaner of products can successfully be matched with a seller or renter of products. Similarly, the more content generators or providers of services, the higher the chance that there are services or that there is content that matches the preferences of viewers or users of services and vice versa. Moreover, data is often essential for successful matchmaking. Platforms usually capture rich data about users and leverage that data to facilitate connections between them.

Differentiation strategies

The indirect network effects, which are typical for multi-sided platforms, promote larger and fewer platforms within the same industry (Evans & Schmalensee, 2005). However, product differentiation can be an important counteraction. Platforms can choose to compete with rivals in a densely populated market niche or instead, choose to target segments that, while oriented to a smaller number of consumers, have less intense competition (Cennamo & Santalo, 2013; Cusumano et al., 2019). Besides, when platforms are able to differentiate in the functions they offer, multiple platforms can successfully coexist (Rysman, 2009).

A platform can change the relation to competing platforms by assembling and structuring a platform ecosystem that is different from that of competitors (Cennamo & Santalo, 2013). This strategy is also called "distinctive positioning". It can be challenging to determine market niches and to decide on the extent of similarity or dissimilarity of the portfolio of applications, relative to its competitors. The degree of difference required to create a distinctive position will depend on the degree to which their competitors embrace various market niches. For instance, in the current generation of video game consoles, the Sony PlayStation and Microsoft Xbox platforms focus largely on the action, fight and sports segments of the market, while the Nintendo Wii console mostly targets general games and platform characters to aim at casual gamers. The research of Cennamo and Santalo (2013) shows that

platform performance will decrease at intermediate levels of distinctive positioning and increase at high and low levels of distinctive positioning.

In addition, platforms can choose for vertical or for horizontal differentiation (Evans & Schmalensee, 2005, 2010; Rysman, 2009). With vertical differentiation, the platform chooses a particular level of quality. Customers can then choose between higher or lower quality depending on their income and relative demand for quality. With horizontal differentiation, the platform focuses on a certain user group. There are, for example, multiple magazines that focus on particular segments of readers and advertisers. Customers may also use different platforms at the same time as they find certain features of different competing platforms attractive.

Control

The research of Boudreau (2010) shows that platform owners who gave up varying degrees of control over their platform experienced accelerated development. Recent research on platforms highlights the complex trade-offs between "open" and "closed" (Gawer & Cusumano, 2014; Van Alstyne et al., 2016b). If platforms are too closed, they risk keeping potential developers out and, as a result, network effects diminish (Van Alstyne et al., 2016b). On the contrary, a lack of control may result in value-destroying effects. Examples are poor quality contributions, misbehaviour that harms others or the platform becoming too varied and fragmented and is hence less useful for both developers and customers (Gawer, 2020). This means that a platform owner must exercise enough control to ensure the integrity of the platform while giving up enough control to encourage innovation by third-party developers (Tiwana et al., 2010).

Control refers to the mechanisms implemented by a platform owner to encourage desirable behaviours by developers (Tiwana et al., 2010). As the platform owner does not hire developers to do a specific task, the relationship between platform owners and third-party developers is not comparable to the classical principal-agent relationship assumed in control theory. Instead, a variety of control mechanisms are observed in platform settings. Examples of formal control are process, input and output control. Process control relates to the methods and procedures that apply to third-party developers. For example, for Apples' App Store, developers need a service development kit and hardware to develop applications (Hein et al., 2016). This limits openness in exchange for high process control, quality and customer satisfaction.

Input control refers to the assessment of the quality of services or products as a gatekeeping mechanism. One way of protecting the platform from unwanted input is by securing the platform (Hein et al., 2016). A comparison of input control can be drawn between the Google Play Store and the Apple App Store. Where Apple follows strict censorship and manual application review processes, Google is less strict and executes only automated reviews. The result is that Apple has fewer security and quality issues and the Play Store has a broader variety of applications. This comparison shows that no or limited input control causes a greater variety of input but entails a decreased quality.

Output control refers to the criteria by which developers' outputs are evaluated, rewarded or penalized. Digitalization allows assets and individuals to be monitored and controlled to a degree that was not previously possible (Gawer, 2020). Platforms can use output control mechanism to check the quality of products or services (Hein et al., 2016). Platforms can implement one way or two-way ranking systems to check the quality of applications or to allow supplier and demand side to rank each other. These mechanisms shift quality assurance to the respective parties and therefore reduce administrative work for the platform owner in a trade-off for decreased control.

Governance structure

Platform governance can be defined as who makes what decisions about a platform (Tiwana et al., 2010). Ecosystem governance is important for building and sustaining the legitimacy of the platform leader as well as for fostering a collective identity for ecosystem members (Gawer, 2014). Platform governance can be centralized or decentralized. When authority and responsibility for making specific decisions are divided between the platform owner and third-party developers, the platform governance is decentralized. Gawer (2014) hypothesized that collaborative governance will increase the incentives for developers to innovate in platform enhancing ways.

A platform can also be proprietary to a single firm or shared by multiple owners (Eisenmann et al., 2006; Eisenmann et al., 2009; Hein et al., 2016). Sharing the platform has benefits as the total market size expands and competition decreases, reducing market outlays. For proprietary control, platforms often need deep pockets and existing relationships with prospective users. In addition, platforms can have a joint venture model, in which several firms jointly sponsor the platform but a single company serves as its sole provider, or a licensing model, in which a single company sponsors the platform and then licenses multiple providers (Eisenmann et al., 2009). Over time, forces tend to push both proprietary and shared platforms towards the licensing model. This hybrid governance model is characterized by centralized control over platform technology and an open provider role. The extent to which a platform owner gave up control can, for example, be measured by equity shares held by independent developers and by the platform owner itself, the extent to which the platform owner is still involved in complementary development and the extent to which outsiders contribute to key elements of the platform, like the graphical user interface (GUI) and the operating system kernel (Boudreau, 2010).

Lastly, a distinction can be made between open architecture and open governance (Van Alstyne et al., 2016a). As mentioned before, open platform boundary resources and an accessible and transparent platform are characteristics of open architecture. Open governance, on the other hand, is related to decision rights and ownerships. It is the extent to which users have the possibility to shape the rules and to share rewards. When a platform has an open architecture but does not share rules and rewards, it gives users the ability to engage but without the incentives to want this. In contrast, when a platform shares rules and rewards but has a relatively closed architecture, it gives potential users the incentives to connect but not the ability to do so. In other words, a suitable open architecture and a fair reward system are key (Van Alstyne et al., 2016b). The latter is true regardless of who is setting the rules.

Healthcare platform design

In addition to the general literature on platform business models, design aspect and strategies, this section will discuss the limited existing literature on healthcare platforms. Based on Fürstenau et al. (2019), healthcare platforms cover a number of value-creating core functions (see table 3). Healthcare platforms follow an ambidextrous strategy of pursuing the dual aims of interoperability and innovation. The vision and strategy priority usually has been set on exploitation, which focuses on improving the interoperability of existing systems. Exploitation is often chosen over, or as the basis for exploration, which focuses on service innovation with app development.

Table 3: Core function of platforms in healthcare

Core function	Expected impact
Information exchange	Enabling information exchange between healthcare providers and patients.
Service integration	Enabling collaboration between healthcare providers and patients by supporting the healthcare processes digitally.
Service innovation	Facilitating innovation ecosystems by connecting healthcare providers and patients with third-party application developers.

The way healthcare platforms realize information exchange and integrate services can be compared to the transaction platform category from literature which is described as *"intermediaries that make it possible for people and organisations to share information or to buy, sell, or access a variety of goods and services"* (Cusumano et al., 2019)(p.22). For the "information exchange" function of healthcare platforms this means, the more connected healthcare organisations, providers and patients, the more useful the platform becomes as more information can be exchanged. Platforms that focus on information exchange can often be described as technology platforms that offer Software-as-a-Service (SaaS)(Nienhuis, 2021b). SaaS is a web-based model that is centrally hosted and maintained in the cloud and usually sold on a subscription basis. For the "service integration" function, the number of users and data is also value-enhancing. Additionally, the more digital content or services that are made available, the more useful the platform becomes. Healthcare platforms that mainly enable connection and collaboration between healthcare providers and patients directly are sometimes also called "collaboration platforms" (Nienhuis, 2021b). Similar to the transaction platform category, healthcare

platforms with the "information exchange" and "service integration" functions are unique and powerful mostly as a result of the digital technology and scale.

The way healthcare platforms innovate healthcare processes, on the other hand, can be compared to the innovation platform category from literature in which platforms *"usually consist of common technological building blocks that the owner and ecosystem partners can share in order to create new complementary products and services"* (Cusumano et al., 2019)(p.22). Innovation platforms create value by facilitating the development of new complementary products and services, sometimes built by the platform owner but mostly by third-party firms, usually without supplier contracts. With complementary in this definition is meant that these innovations add functionality or access to assets that make the platform increasingly useful. In healthcare, technology platforms belong to this category when they offer open APIs and a developer portal that enables third-party applications to easily access the platform (Nienhuis, 2021b). The network effects come from the increasing number or utility of the complements. The more complements or the higher the quality, the more attractive the platform becomes to users, as well as other potential market actors such as investors.

In addition to the categorisation of technology and collaboration platforms in healthcare, some other categories can be distinguished. Similar to Amazon and Airbnb, some platforms in healthcare offer marketplaces to match the supply of care with the demand for care. Besides, similar to PayPal which offers payment services, service platforms exist that offer certain services like home monitoring. However, as most collaboration or technology platforms also offer these functionalities, it was decided to leave these categories out of the scope of this study.

Information exchange

The main goal of healthcare platforms is to enable healthcare providers to share information in a timely and cost-effective manner. Health information exchange is an inevitable part of current reforms in the national healthcare system (Yaraghi et al., 2015). It includes multiple unique but interdependent sides. Examples are patients and providers within different healthcare organisations, like hospitals, general practices and pharmacies. The value that is derived by each side is unique but dependent on the participation and engagement of the other sides. Research by Yaraghi et al. (2015) empirically showed that the organisations with a higher number of shared patients, a larger market share and a higher dependency on major organisations will exchange health information faster than others. This shows that network externalities are crucial for platforms to realize large scale information exchange. However, big challenges are that health information is of high business value and sharing such information with competitors is considered a risk to strategic market advantage. Organisations may also be reluctant to use a platform for information exchange because they do not see any direct financial benefit. Finally, technology-savvy organisations may be more willing to accept the new technology than their non-savvy peers. These and other attitudes negatively affect the level at which platform can realize health information exchange among providers.

Service integration

Platforms that enable service integration offer the possibility for healthcare providers to actively collaborate (Cusumano et al., 2019). Similar to transaction platforms, they create and deliver value by facilitating interactions, for example, by enabling users to create and share content. Healthcare platforms can do this by bringing patients and healthcare providers from different organisations together on their platforms. Then, the role of the platforms is to enable access to digital content and services that support collaboration among their users, like referring and transferring patients between organisations.

For providers within different organisations to collaborate, interoperability is necessary (Fürstenau et al., 2019; Stegemann & Gersch, 2021; Yaraghi et al., 2015). Interoperability is a prerequisite to be able to combine services from different healthcare providers, allowing for information exchange and transfer as well as the design of continuous treatment and joint care pathways. Interoperability is generally defined as *"the ability of two or more systems or components to exchange information and to use the information that has been exchanged"* (Chen et al., 2008)(p. 648). Interoperability is the way in which the platform fosters the flow of value by making connections between users.

A distinction is made between technical and semantical interoperability (Stegemann & Gersch, 2021). Technical interoperability is focused on the connections of systems through IT-infrastructures. These are the technical issues related to the different protocols, formats and interfaces for which interface standards must be introduced to ensure interoperability. Semantical interoperability refers to the meaning of the exchanged data and the ease to understand the transmitted message. Difficulties arise when different systems use a different concept for similar or identical concepts. In order to exchange information between a lot of different systems and applications, semantically interoperable data is required. In other words, the exchanged information must be able to be uniformly interpreted and understood. In general, interoperability can be achieved through the use of standards, especially open standards. However, across the world, countries have not been able to reach a consensus on interoperability issues in healthcare for decades (Furstenau & Auschra, 2016; Fürstenau et al., 2019; Nienhuis, 2021a; Stegemann & Gersch, 2021).

Service innovation

Healthcare platforms with the "service innovation" function, facilitate innovation ecosystems by connecting healthcare providers and patients with third-party application developers. A key competitive parameter for healthcare platforms is to achieve direct network effects through standards and interfaces, as well as competitive advantages through the design of the integration and binding of complementors and customers (Fürstenau et al., 2019; Stegemann & Gersch, 2021). Platforms have the potential to accelerate healthcare innovation when they provide a certain degree of openness within the platform's ecosystem. As mentioned, open platforms can be achieved when the platforms start to offer well-defined, published APIs allowing for complements by others (Eisenmann et al., 2009). Open platforms can also help to overcome the fragmentation of healthcare services, such as care pathways that do not adhere to silos, like many chronic diseases. Despite their potentials, there are still few examples of open platforms in healthcare.

Practices of engaging with the wider environment do not only require standardization but also the management of regulatory issues. Especially in highly regulated markets, such as healthcare, platforms need to cope with regulations, laws and informal expectations regarding security and privacy, certification and quality control (Furstenau & Auschra, 2016). The challenges related to control are particularly challenging as, in the worst-case scenario, lives are at risk when a platform fails. However, too strict control may discourage potential users and thus prevent the platform from scaling. This means that, in extension to other markets, a healthcare platform has to balance the interests and goals of multiple parties as well as underlying issues of accountability and liability. They need to carefully consider the type and degree of openness when implementing and scaling a digital healthcare platform.

Methods

A case study is the intensive analysis of a small number of cases where the goal is to understand a population of cases (Seawright & Gerring, 2008). In this study, the analysis of a small number of platform companies in healthcare is performed with the goal to understand healthcare platforms. A lot is known about platforms in general, but little is known about platforms in the Dutch healthcare context. Case studies are considered an appropriate method to produce this context-based knowledge (Eisenhardt & Graebner, 2007; Flyvbjerg, 2006). The reasons for this are that they are able to cover contextual conditions that are expected to be relevant to the phenomenon under study and that they can clarify the boundaries between the phenomenon and its context (Baxter & Jack, 2008; Yazan, 2015). Another reason for choosing the case study methodology is its possibility to focus on answering "how" and "why" questions concerning the phenomenon of interest. The case study protocol of Eisenhardt (1989) was used as a guideline for the case study methodology (see appendix II).

In this study, an explorative multiple-case study was executed (Baxter & Jack, 2008; Kyburz-Graber, 2004). The explorative case study uses an interpretive process to provide an understanding of the case. This is valuable because healthcare platforms are relatively new phenomena and limited literature exists about them. Besides, the existing platforms differ from each other in that they come from different backgrounds, where some platform companies have multiple years of experience with information exchange in healthcare and others recently launched their company. The platforms also seemed to have designed and differentiated their platforms in different ways by focussing on specific architectures or user groups for example. The inclusion of multiple cases enabled the exploration of the differences within and between the healthcare platforms.

Case selection

The selection of the correct cases is necessary to ensure good case study research (Seawright & Gerring, 2008). The goal of case selection is a representative sample and a useful variation on the different elements of the theoretical interest. To do so, theoretical sampling was used, instead of random sampling (Eisenhardt, 1989). The kind of healthcare platforms that were included in this study are at least able to make connections between HISs, between HISs and Personal Health Environments (PHEs), used by patients, and between HISs and healthcare applications. These kinds of healthcare platforms could at least be characterized as transaction platforms and they were also expected to use strategies from the innovation platform category. The specification of the population was necessary to constrain variation and improve external validity (Eisenhardt, 1989).

In combination with publicly available information about the potential relevant healthcare platforms, seven companies were expected to be relevant. From these companies, the four healthcare platforms with the most diverse backgrounds and the highest levels of access to key persons were selected. Healthcare Platform 1 (HP1), Healthcare Platform 2 (HP2) and Healthcare Platform 3 (HP3) are incumbent initiatives, where HP1 and HP2 are vendor-led and HP3 is provider-led. Besides, Healthcare Platform 4 (HP4) is a vendor-led, new market entry. See also table 4 for a description of the selected cases. Based on the course of data collection and data analysis, the option was also kept open to exclude and include cases during the process (Eisenhardt & Graebner, 2007). This would have been the case when not enough information could be obtained or when a new relevant case would have come to the attention. This has not been the case for this research.

The four selected cases can be considered critical cases. A critical case can richly describe the existence of a phenomenon and is the opposite of a typical case. The latter is more suitable for explanatory research and is used to confirm or disconfirm or to double-check an existing theory (Seawright & Gerring, 2008). Besides, it is chosen to include multiple cases in the study. Considering the time restriction, a trade-off needed to be made between the number of cases and the extent of data collection and analysis. In other words, a choice had to be made between obtaining insight into multiple platform companies and obtaining extensive insight in only one or two companies. Since the goal was to understand the general concept of platforms in the healthcare industry, more value was attached to generalization. It was decided to include four cases, which means that less information could be collected per platform company, but where the number is not yet too high to carry out a sufficiently extensive exploration and analysis. The inclusion of more cases would risk to result in an incomplete collection of the relevant data and an analysis that is not extensive enough. The inclusion of fewer cases

would risk to result in insufficient support for the healthcare platform phenomenon. For theory building, multiple cases generally provide a stronger base for the existence of a phenomenon (Siggelkow, 2007). Reasonably, more cases can clarify whether findings are distinctive for a single case or replicated by multiple cases (Eisenhardt & Graebner, 2007). Moreover, multiple cases can result in a more grounded theory, because more varied empirical evidence can be provided.

*Table 4: Description of cases *Small: <50 FTE, medium: <250 FTE, large < 1000 FTE*

Firm	Size*	Industry and scope	Unit of analysis		Data sources
			Platform strategy	Size*	
HP1	Large	Healthcare ICT company - National	Platform as a service to support own HIS users	Small	● In-depth interview consultant (87 min) ● In-depth interview consultant (35 min) ● Firm website ● Document with an in-depth session about the platform
HP2	Large	Healthcare ICT company - International	A platform for organisations to connect to other organisations and applications	Large	● In-depth interview consultant and manager (75 min) ● In-depth interview consultant and manager (44 min) ● Firm website ● Mail conversations
HP3	Small	Cooperative healthcare institution - National	Platform as an environment for healthcare providers to work together in care networks	Small	● In-depth interview founder (64 min) ● In-depth interview founder (34 min) ● Firm website ● Document with an in-depth session about the platform
HP4	Medium	Technology company - International	A platform that connects applications to healthcare organisations	Medium	● In-depth interview founder (58 min) ● In-depth interview founder and manager (38 min) ● Firm website ● Mail conversations

Data collection

In this study, the data was collected from multiple data sources, namely: (1) two in-depth interviews with managers or consultants per platform company; (2) mail and phone conversations to support or clarify the results from the interviews; (3) consultations with experts; and (4) firm websites, publicly available documents and press releases. See also table 4 for the used data sources per case. The use of multiple data sources is an example of a procedure that is called triangulation and it is one of the quality criteria that is incorporated in this case study research (Eisenhardt & Graebner, 2007; Flyvbjerg, 2006; Kyburz-Graber, 2004).

As already mentioned, the disadvantage of including multiple cases is that limited information can be collected. Although it is often recommended to involve multiple informants per case (Eisenhardt & Graebner, 2007), it was chosen to conduct two interviews with one, and whenever possible, two main informants per platform company. However, to ensure the reliability of the results, several measures were taken. Firstly, it was ensured that the informants are competent to discuss all relevant information about the platform business model and strategies within the company (Kumar et al., 1993). Secondly, the informants were given the possibility to discuss the answers anonymously to increase the likelihood that the informant will disclose important information. Thirdly, the focus in the questions was on the platform itself, instead of on the opinion of the informant, to limit informant bias (Faems et al., 2008). The informants were also contacted for a follow-up when clarification on certain topics was necessary. Fourthly, expert opinions and publicly available documents were used to complement the findings from the interviews (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Faems et al., 2008). Finally, when it turned out that a lot of information was still missing in a certain case or when there was a lot of informant bias, it was decided to conduct an additional interview with another informant at that company. For HP2 and HP4, two interviews with two informants were conducted and for HP1 and HP3, two interviews with the same informant were conducted.

It was chosen to conduct in-depth interviews, because they can provide much more detailed information than what is available through other data collection methods, such as surveys (Boyce & Neale, 2006). Besides, it was decided to conduct semi-structured interviews to ensure consistency between interviews, thus increasing the reliability of the findings. An interview protocol was developed which include the instructions and the themes and subthemes that were discussed in each interview (see appendix III). The protocol was used as a tool to ensure that all relevant topics would be discussed. The interviews were prepared by studying the firm through publicly available documentation, like the firm′s website, and by collecting information from the platform experts within the consultancy agency M&I/Partners. The obtained information was necessary to better interpret the informants′ answers. In addition, the interviews were recorded with the consent of the respondents, and transcribed, anonymized and analysed afterwards. In the first instance, the aim was to schedule two hours for the interviews. If this was not possible, the minimum duration of one hour was maintained.

Furthermore, the role of theory took different forms, which is common in case study research in general (Walsham, 1995). The theory on platform strategy served in the first place as an initial theoretical framework. The theoretical framework was used as a base for the themes that were discussed in the interviews (see appendix III). Besides, during the collection of information about the selected healthcare platforms, the information was compared with existing platform literature. In this way, platform theory was also a part of an iterative process of data collection and analysis. Finally, after finalizing the case studies, new insights about healthcare platforms also served as parts of new theories. For the latter, it holds that each case represents its own analytical unit that can be seen as experiments that serve as replications, contrasts, or extensions to the emerging theory (Eisenhardt & Graebner, 2007).

Data analysis

The analysis was a lengthy and complex process that included several phases. The first steps were to listen to the interview tapes, transcribe the interviews and read the transcripts several times. The next step was to write case histories of all platform companies. This was done to structure the information about the cases and to get a first rough understanding of the cases which helped in further analysis (Eisenhardt, 1989). The case histories include the origin, the main business models and design aspects of the companies. Iterations between the voice record, case history and contact with the informants were part of the process to arrive at the final version of the case history.

The next step was to conduct the deeper within-case data analysis in which the collected data from the qualitative research was coded (Basit, 2003). In this phase, coding statements, choosing categories, linking themes and selecting quotations, were part of the process. The text that was collected within the qualitative case studies is not yet meaningful for the research nor the outside audiences. Words and their meanings are closely linked, but raw data needs to be systematically analysed to understand a social situation. By creating categories that are linked and give meaning to the chunks of text within the collected raw data, a conceptual schema could be constructed that suits the data (Hyde, 2000; Miles & Huberman, 1994). This schema helped to find relevant phenomena, collect examples of those phenomena and to detect patterns and structures within those phenomena. The analysis of the data from interviews took place in the program ATLAS.ti. The program supports the process of coding and organises the collected data into one clear environment (Basit, 2003).

In the first-order analysis, open coding was used in which the researcher tried to adhere as much as possible to respondents′ words. It was expected in advance that platforms in a healthcare context differ from the theory on platforms in general. Therefore, the characteristics that are unique to healthcare platforms were key. This can be seen as the theory-building or the "grounded" part of the approach. Besides, in this first phase, no categories were yet created which resulted in a long list of codes. After coding all eight interviews, over 150 codes were created. This stage was overwhelming, but as Gioia rightfully stated: *"You gotta get lost before you can get found"* (Gioia et al., 2013).

The next step was part of the cross-case analysis in which the codes that were found in the individual cases were compared with each other to search for similarities and differences (Eisenhardt, 1989). This type of coding is also called axial coding. The analysis resulted in around 30 categories, which is a more manageable number of categories compared to the previous phase. In this second-order analysis, the researcher looked at both the level of first-order codes, adhering to respondent′s words, and the more abstract second-order theoretical level, where was tried to create categories that help to describe

and explain platforms in healthcare. In this stage, there was referred to the theoretical framework, where themes were occasionally adjusted to more applicable terms that are used in existing platform theory. This can also be considered as the deductive or theory testing part of the approach. In the last step, the aggregate dimensions or pillars were assigned and three data structures were made. The data structures allowed the researcher to configure the data into a visual aid and to provide a graphic representation of the way the data was progressed from raw data to codes and categories in conducting the analyses.

Important as one of the final steps in the analysis is to deal with the issue of interpretation (Gioia et al., 2013). As this research is conducted by only one researcher, a limitation is that only one interpretation is included in the analysis. To minimize this effect, the researcher′s supervisor, who is also an expert in the area of Dutch healthcare platforms, was asked to look over the case histories, codes and categories. When he had remarks about some codes, the topic was discussed and the data was revisited to arrive at a more consensual interpretation.

In the final phase, the goals were to generate grounded theory from the data structures and to write it all up in a coherent fashion. As the data structures are still static pictures of a dynamic phenomenon, a model was developed that make the dynamic relationships among the second-order concepts and pillars more transparent. The model has the goal to support the explanation of platforms in healthcare and the relevant data-to-theory connections (Gioia et al., 2013).

Trustworthiness

To ensure trustworthiness, four criteria were taken into account (Shenton, 2004). These criteria include credibility, transferability, dependability and confirmability. Different strategies were used to ensure the fulfilment of the criteria in this study.

Firstly, credibility or internal validity was ensured by the use of chains of evidence, member checks and triangulation. A chain of evidence was maintained by continuing to pay attention to the link with the research question during the collection and analysis of the data and the description of the results and conclusions. Member checking was done by returning the summary of each interview and consultation to the participants to check for accuracy and resonance with their experiences. Any subsequent comments and additions were incorporated in the further analysis of the information. These checks are useful since they let participants verify the researcher′s emerging theories. Triangulation is applied by the collection of data from multiple sources. Triangulation is valuable since it makes it possible to verify the data from more than one source (Yazan, 2015).

Secondly, transferability or external validity was improved by thick description. To do so, all relevant findings about the different healthcare platforms and their context were discussed in detail. Tables and graphs with overviews of within-case and cross-case characteristics were made to support the thick description and to provide more clarity. The thick description in combination with tables and graphs made it possible to make comparisons between the cases and with other studies (Shenton, 2004).

Thirdly, dependability or reliability was ensured through the use of a case study protocol (Yazan, 2015). In this study, the case study protocol of Eisenhardt (1989) was used to determine certain characteristics of the methodology. This helped to systematically draw from previous knowledge and to reduce misperceptions.

Lastly, confirmability or the objectivity of the study was improved by recognition of the shortcomings and by describing the possible effects of these shortcomings on the findings. Besides, several measures were taken to reduce the effect of predetermined limitations. It was, for example, already clear beforehand that the biggest limitation of this study is the limited number of interviews due to the time restrictions. One or two interviews would probably not result in data saturation which is needed to confirm that all relevant information from that case is collected (Boyce & Neale, 2006). The most important measure that was taken to reduce the negative effect on the findings, is that multiple data sources were used.

Ethical considerations

The following ethical aspects were taken into account during the research: consent, voluntary participation, confidentiality and anonymity. This was done by informing each potential respondent about the study before he gave consent to participate. This means that it was shared what the research goals are; how confidentiality and anonymity of the information about the respondent are taken into

account; that participation in the study is voluntary and that everyone can withdraw from the study at any time without explanation. This was discussed verbally with all respondents and they were asked, after the recording started, to indicate their willingness to participate in the research.

Each respondent was also informed about the public availability of the final version of the thesis and got the possibility to choose whether the company name could be mentioned in the research. The respondent got two options to choose from, namely: the company name can be mentioned under a pseudonym, where specific information can be linked back to this pseudonym; or the company name can be mentioned, so that specific data can be linked back to the company name. As, except for one respondent, all respondents chose the first option, all company names are mentioned under a pseudonym in this study.

After the collection of the data, participants received the researcher′s contact details which they could use for questions or remarks. The respondents also received a summary of the research results once the research was completed. In addition, the research proposal is assessed by the ethics committee for Behavioural, Management and Social sciences (BMS) of the University of Twente. This was done to confirm that the research is conducted in an ethically responsible manner.

Results

In this section, the results of the within-case and cross-case data analysis are discussed. For the analysis, the collected data from the qualitative research is coded per case. The first-order concepts are divided into second-order themes and the second-order themes are divided into pillars. These pillars are the three main functions of healthcare platforms, namely: information exchange, service integration and service innovation. First, the main findings per case are discussed (see also appendix IV for a more detailed description per case). In the second part, the results are discussed per pillar and per second-order theme.

Healthcare platform 1

HP1 was founded in 1986. They started by offering a billing program for medical specialists. Over the years, their product has grown into a fully integrated HIS/EHR (Health Information System/Electronic Health Record). In 2017, HP1 introduced their healthcare platform as an addition to their HIS, intending to enable better information exchange between the different systems in healthcare. The platform provides, for example, connections with PHEs, resulting in more opportunities for its users to involve patients. Besides, the platform is a fully managed environment by HP1 in which data minimization is a design aspect.

Other than the other platforms in this study, HP1 is also a supplier of HIS software. HP1 uses this to their advantage as information needs to be exchanged between information systems for healthcare providers within organisations to exchange information. HP1′s strategy is to use the platform as a gateway towards their own HIS users and for them to make connections to the outside world. In the same way, HP1 offers the only entrance to the networks of initiatives. This makes HP1′s own HIS customers dependent on them for certain services, which can be seen as a form of vendor lock-in. For connections to other parties, HP1 charges high costs or has high requirements. They only work together when they or their customers are willing to invest and when the other party uses the same open standards so that no major time investment has to be made to realize custom-made connections.

Besides the information exchange between organisations and patients, HP1 can also connect healthcare applications. Nowadays, the platform and its connected applications offer extensive support for transmural collaboration in healthcare, like the mutual referral and transfer of patients, joint treatment, monitoring and consulting of patients and remote care. Their ambition is to provide a platform for "open care" and, together with partners, accelerate the development and use of healthcare innovations. Their goal is to enable automatic onboarding to be able to save time to connect applications. They do this by investing time to agilely design their developer portal and widely applicable APIs. Once the applications are ready to use, healthcare organisations themselves are responsible to check the quality of applications and decide on the applications they want to use. Additionally, HP1 maintains a trust model in which applications are monitored on permissions, prescriptions and technical functionality.

Healthcare platform 2

HP2 was founded almost 40 years ago with a focus on communication in healthcare. Over the years, they developed their platform as a complete solution for information exchange and collaboration between healthcare organisations, consisting of three modules, namely: a) communication services, which include chat, message and mail services; b) technical integrations for information exchange between organisations; and c) their own collaboration applications.

Exchanging information in healthcare has always been HP2′s core business. However, HP2 is currently making a transition to combine their solutions for information exchange with their collaboration applications. Several applications are recently added to their product offering in which healthcare providers can work together to improve certain healthcare processes. In an interview, a representative mentioned the following about the reason they started to offer these applications:

> *"We see that this information exchange is becoming easier to realize. So that means that information exchange in itself is no longer the essence, but actually more, how do you then support those care providers in collaboration. And for that, let's say, those collaboration applications are valuable."*

The core of HP2's platform is strategic proprietary product development that is specific to information exchange in healthcare. In the course of their existence, they built a community of Dutch healthcare providers and organisations that made use of their growing number of modules including several solutions for the exchange of many different types of information. They are now able to offer new solutions, like collaboration applications that are easily accessibly to customers within their community. HP2 serves their customers by providing a complete solution for their use case by putting together the optimal combination of services or functionalities from the different modules.

In addition, HP2 uses a selective buy-and-build strategy to expand their assortment of applications. This enables them to strengthen their position in the healthcare communication market as they can combine their solutions for technical integrations, which are often subsidized in incentives schemes or obliged by laws, with these collaboration applications. Different from HP1 and HP4, the platform does not have a second side that opens up to third-party application developers. Instead, the platform mainly focuses on end-users. Related to this, HP2 offers consultancy services as part of its competitive strategy. These services have the goals to help organisations overcome the natural resistance to adopt a platform, to understand the advantages and disadvantages of their platform relative to competing alternatives and to collaborate better digitally.

Healthcare platform 3

HP3 was founded three years ago with the goal to make digital collaboration in healthcare networks legally possible and scalable. As a cooperative healthcare institution, HP3 is a membership organisation where the General Members' Meeting determines the decision-making. The members consist of healthcare providers and healthcare organisations. Practically, HP3 offers its members a care network environment where providers from the same care pathways can digitally work together and use the functionalities of the platform to support their healthcare processes.

For healthcare providers to work together on HP3′s platform, it is a prerequisite that the systems of the organisations in which they work can digitally exchange information with each other. This means that the HISs of these different organisations should be connected. To do so, HP3 partners with other platforms that already realized networks of connected information systems of different organisations. For information systems that are not yet connected, HP3 enters into partnerships with HIS suppliers and builds the connections with the systems themselves.

Care pathways play a central role in the care network environment of HP3. Within care pathways, patients often have to deal with a lot of different healthcare providers from different healthcare organisations. Examples of these pathways are COVID19 care, chronic care and obstetric care. The platform of HP3 supports these pathways by bringing together information from different providers and by making it usable in dashboards. The platform also offers and gives access to eHealth functionalities which can be used to digitally support the healthcare process. Another important design aspect is the direct connection of the platform with its own PHE. This connection ensures that patients can access all the information that is collected about them. eHealth functionalities, that are build in or connected to the platform, are also directly accessible through the PHE. This enables extra functionalities in the interaction between healthcare providers and patients, for example in the form of remote healthcare or telemonitoring. As HP3′s PHE works seamlessly with their environment for providers, healthcare providers and patients can be seen as the two sides of HP3.

Healthcare platform 4

HP4 is a two-year-old start-up that makes information systems available for information exchange. HP4 is a technology company that builds infrastructures for all kinds of information systems and that is able to translate these into a standard API for connections to applications. One of the goals of HP4 is to solve the problem of interoperability in Dutch healthcare. They want to replace the existing but outdated and expensive point solutions with integrations via their platform. They introduce platform thinking by offering a platform that connects, discloses, translates and sends healthcare data via their uniform APIs between healthcare organisations and applications. They also remove the financial hurdle for healthcare organisations by investing in reusable infrastructure and connections themselves and by not charging healthcare organisations for it.

For healthcare providers to use applications, information needs to be interchangeable with the information systems of organisations. To do so, HP4 has a strategy to enter into partnerships with HIS suppliers. These suppliers receive a lot of requests from their customers for integrations with other systems and applications with the goals to collaborate or add functionality. In an interview, a representative of HP4 mentioned that they ensure that data can go back and forth between all systems and applications in which they act as a friend of the HIS. At the same time, HP4 offers the suppliers a new revenue model that is based on sharing a portion of the turnover, which is a percentage of the fee that HP4 receives from the application owners.

The biggest difference with the other healthcare platforms is HP4′s price strategy. HP4 offers free integrations with information systems and applications and free maintenance of these integrations. Only applications pay a transaction fee. The goal of the price strategy is to remove the hurdle to start using their platform. As applications pay costs that depend on the extent to which the application is used by users of the platform, it becomes feasible for new, small or foreign applications to connect to the platform. Also smaller healthcare organisations, that previously could not afford the costs of a platform, are now able to start using a platform. The growing number of users reached in this way enhances indirect network effects for both healthcare organisations and applications. This strategy is very different from the strategies of other platforms and HP4 is convinced that this gives them a unique proposition.

HP4 develops APIs that can be used by app developers to connect to the platform themselves. HP4 has a website for developers, including all available documentation, and a sandbox environment for testing. HIS suppliers that make their HIS available through the platform gain access, but retain full control over the applications and integrations allowed by the platform. The third parties that are approved by the supplier can integrate with the information system and offer their solutions to the supplier′s customers. For healthcare organisations, HP4 offers an app store that is independent of their information system. In this way, organisations become less dependent on HIS supplier as providers can keep using the platform′s applications when the organisation switches to another supplier. Besides, HP4 wants to create a competitive landscape of applications where organisations have to select the application that they want to use themselves. HP4 does some input control, in which they assess the safety and security of applications and output control, in which they monitor applications on technical functionality, but organisations have to assess content quality themselves.

Cross-case analysis

In the cross-case analysis, the codes and categories from all cases were identified and compared with each other to search for similarities and differences. In appendix VI, an overview can be found of all codes and categories that were identified for each case. The codes and categories were divided into three pillars, namely information exchange, service integration and service innovation.

Information exchange

The analysis of the results shows that in each case the platform is occupied with information exchange between healthcare organisations. As information exchange between healthcare organisations is often still not realized, the first task for healthcare platforms is usually to enable this. Only when the information systems of the organisations can exchange information with other organisations, the platform is able to offer service integration or innovation. In all cases, the complexity of the Dutch health information exchange landscape was mentioned. Appendix V can be consulted for a compact overview of the most important components. Besides, figure 4 includes the data structure of the ″information exchange″ pillar.

Offer software-as-a-service

In cases 1, 2 and 4, the representatives mentioned that one of the goals of the platform is to unburden healthcare organisations by giving them the possibility to let the platform take over all connection with external organisations and applications. As a lot of healthcare organisations do not want to be concerned with all connections, they offer SaaS in which the healthcare organisations pay on a subscription basis and the platform hosts and maintains the connections.

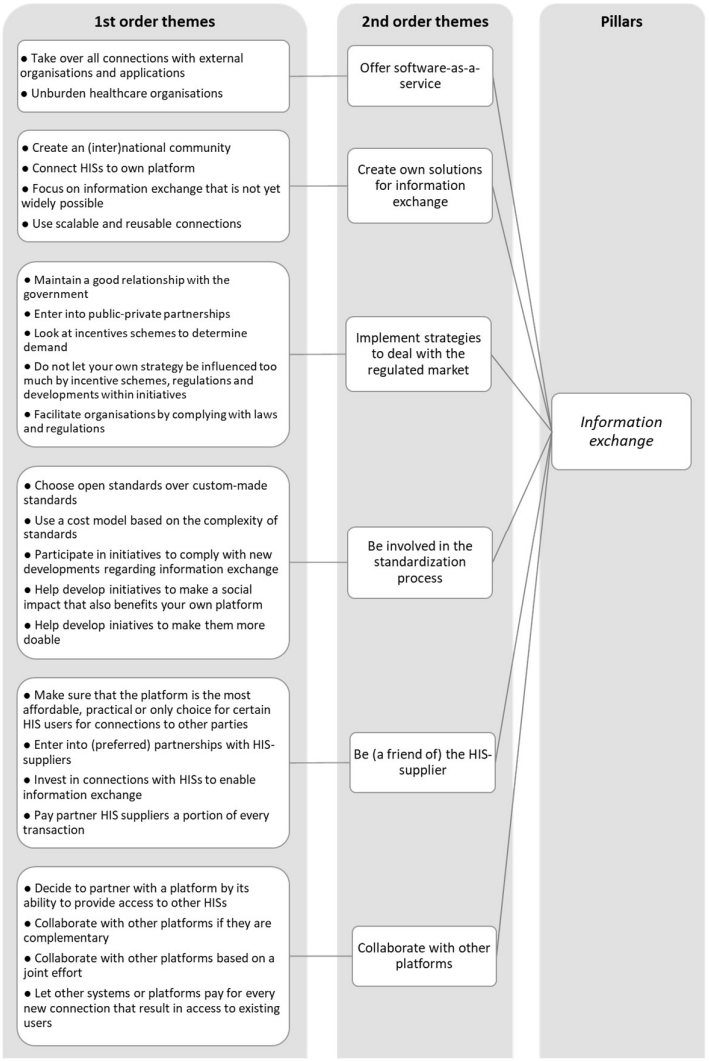

Figure 4: Data structure for the "information exchange" pillar

For platforms, it is a challenge to use the various existing infrastructures smartly. It must be considered where infrastructures can be reused, where new infrastructures must be built and where certain infrastructures can be linked together. In all cases, the representatives indicated that they participate as much as possible in initiatives that already provide a network of connected systems. Examples are initiatives I and II and the National Exchange Point (NEP)(see appendix V). These are used for connections to PHEs, for exchange of documents and images between HISs and for exchange of medication and GP summaries between HISs respectively. However, all initiatives are in their infancy and it can still take a while before they realize national infrastructures. Therefore, the platforms also need to provide connections to PHEs and HISs themselves. They can do this by using their own APIs or XDS infrastructures or simpler communication services for information exchange, like chat, message and mail services. In figure 5, a schematic overview is shown of the connections the platforms from the cases can provide.

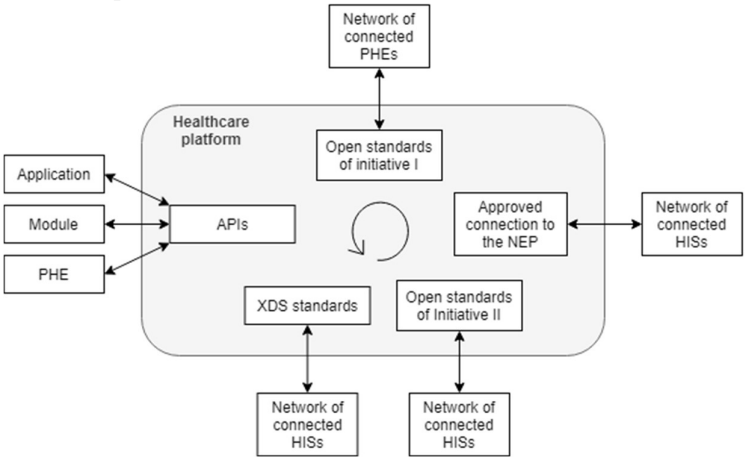

Figure 5: Functions and interfaces of healthcare platforms in general

Create own solutions for information exchange

In all cases, the platforms have different solutions for information exchange. Cases 1 and 2 consist of companies that already exist for a longer time. Over the years, they built communities of organisations that started to use their solutions. HP1 built a community of all customers that use their HIS system. They try to maintain their community by offering functionalities on their platform that are focused on the needs of these customers. HP2, on the other hand, is supplier independent. They created a community through their mail and integration services, which now consist of a network of over 250 connect HISs and a healthcare community of over 100.000 healthcare providers. In addition, HP2 offers collaboration applications in which other compositions of collaborating healthcare providers originated over the years. This means that HP2′s combination of different solutions enforces the different communities they created.

For HP3, information exchange is a necessity to make it possible for the healthcare providers on their platform to exchange information. Only when the information from the organisations′ systems is accessible, it is useful for providers from different organisations to use HP3′s platform and its functionalities to digitally support care processes. Therefore, they try to make use of existing solutions, like the XDS network of HP2. Sometimes they are forced to make connections themselves:

> *"We are actually focused on making data functional, that's our core business. We realize that all that data has to flow and because that is going too slowly, we have actually become a service provider as well. More from a necessity because it did not happen, than that we were very happy to be it ourselves."*

When HP3 needs to make connections itself, they try to make strategic decisions to enhance network effects as much as possible. They enter into partnerships with suppliers in which they invest in the connection to the information systems themselves. An example is their collaboration with a supplier of a HIS that is used by almost all GPs and pharmacies. As these healthcare organisations are considered as the keys in healthcare, they created a strategic advantage. Besides, HP4 creates its community of healthcare organisations by entering into partnerships with HIS suppliers, where they agree to become the preferred partner for connections to all outside parties.

As for certain exchanges nationwide infrastructures already exist, it is of added value to focus on information exchange for which large-scale infrastructures do not yet exist. For example, the exchange of Health and Care Information Models (HCIMs) between HISs is still not realized in many instances. This is considered a big challenge since the information models are often not yet registered in the same way in different systems. Representatives of HP2 and HP4 mentioned that their fundamental principle is to use scalable and reusable connections. They translate the data from the different systems to one uniform API, largely based on FHIR, and use that API for connections to all other systems.

Implement strategies to deal effectively with the constraints of the regulated market

In all cases, the role of the government was mentioned. A representative of HP2 mentioned that the Ministry of Health, Welfare and Sport (VWS) is simply the most important guiding organisation for healthcare in the Netherlands and increasingly also for healthcare ICT. A representative of HP1 indicated that the government wants to give the market as much freedom as possible. However, if the government gives the market too much freedom and the pace of innovation is too slow, then the government has to interfere. Roughly speaking, they interfere by stimulating and by obliging. They stimulate by providing incentive schemes and they oblige by introducing laws or regulations for the realization or digitization of certain exchanges or functionalities. A representative of HP3 mentioned the following about the combination of incentives schemes and laws and regulations:

> *"You have to bring the sweet and the sour together. If it becomes non-committal, all those incentive schemes and things, then it won't work. And if no consideration is given to the structural safeguarding and sustainable effects of this system, such incentive schemes can have the wrong effect."*

The representatives from HP1 and HP4 also mentioned an example where the government supports and funds two large platforms, among which HP2, as part of an initiative. These platforms were appointed to jointly determine which technical agreements have to be made to enable a link between the mutual existing XDS infrastructures. The intention is to make these agreements publicly available and it is likely that the government is going to provide incentive schemes based on these agreements. However, before this is realized, all other platforms are in uncertain positions. A representative of HP4 mentioned the following about this:

> *"It is very good that standards and agreements are being made at a national level, but not by two commercial parties who just want to keep each other afloat. And especially the annoying thing is that we had customers who said, "oh, we want your XDS", and then they said, "Oh but wait a minute, let's see what happens there". So then we had to wait again."*

The above example of a public-private partnership emphasizes that it is important to maintain a good relationship with the government and to enter into strategic partnerships with them. However, the government is sometimes reluctant to collaborate with platforms or other ICT suppliers. A representative of HP1 mentioned that there is a top-down mentality at the ministry and that ICT suppliers are not always taken seriously. According to the representative, the government has certain prejudices about the commercial interests of suppliers that make them unwilling to cooperate. Instead, they sometimes only collaborate with healthcare organisations that do not have sufficient knowledge about certain ICT choices, resulting in unfeasible incentive schemes or regulations.

In all cases was indicated that the incentive schemes stimulate customer demand and that it is important to keep an eye on them to align the functionalities of the platform with the functionalities that are stimulated through incentive schemes. However, all representative indicated that the Dutch healthcare market is very subsidy driven. A representative of HP3 for example mentioned that the incentive schemes are disruptive because no own initiative is taken anymore. Other challenges that were mentioned are that the incentives schemes do not always fit with what is needed in reality, usually offer short-term solutions and only provide one-off costs and no structural costs.

HP1 and HP2 deal with these challenges by offering additional solutions that build on subsidized solutions. A representative of HP2 mentioned that the incentives schemes mainly stimulate technical connections. When these have been realized, it is suddenly much easier and cheaper to purchase extra functionalities that can digitally support healthcare processes. For example, HP1 and HP2 offer collaboration applications that are not stimulated by incentive schemes but have become attractive to their customers as they have realized the technical integrations through incentive schemes.

The representatives of HP1 and HP2 also indicated that they do not let their strategy be influenced too much by incentive schemes. A representative of HP2 mentioned for example that healthcare organisations are increasingly looking for solutions that must fit within their vision and a representative of HP1 mentioned that they also want to focus on solutions that are not subsidized, but are very relevant and add a lot of value to their customers. Furthermore, HP4 does not want to be distracted by incentives schemes at all and completely wants to go its own way by sticking to its strategy. They want to make strategic choices and not choices based on incentive schemes. In one of the interviews, a representative of HP4 even indicated that they have returned a subsidy at some point because it deviated too much from their strategy.

Besides the use of incentive schemes, the government also started to introduce more and more laws and regulations. The ultimate goal of the new laws, such as Wegiz (Law for electronic information exchange in healthcare), is to make electronic information exchange compulsory throughout the Dutch healthcare system. This can bring great advantages for platforms, like HP3, that offer functionalities for which information exchange is a precondition. A representative of HP2 mentioned that new laws will result in more necessary certifications and NEN standards and that healthcare organisations are finding it increasingly difficult to keep track of the nuances within laws, rules and standards. As platforms can unburden healthcare organisations by taking care of the increasing amount of requirements, some new laws and regulations can stimulate organisations to start using a platform. However, the representatives also mentioned that implementing laws is difficult and that it takes a long time for the results to become visible.

Take initiative in the standardization process

For the healthcare industry in general, but also for ICT suppliers, sustainable interoperability is becoming increasingly important. One of the most important reasons for ICT suppliers, as well as platforms, to pay attention to sustainable interoperability and ineffective spending of healthcare money is to prevent the government from taking control and to limit their dependence on them.

At this moment, Dutch standards develop themselves at a fast pace in which increasingly more information can be exchanged between HISs of healthcare providers and PHEs of patients. In all cases, the representatives mentioned that they preferably use standardized APIs to avoid developing supplier-specific software. However, standardization in Dutch healthcare is aimed at information exchange for specific situations. Existing initiatives include separate trust frameworks, based on different technologies and standards. For new situations, like the exchange of the nurse transfer, new standards, agreements and APIs are needed. This means that there is no sustainable interoperability, but situational or ad hoc interoperability. Every time new information can be exchanged, a more extensive set of APIs is needed. This software is often complex and needs to be developed and maintained by software developers and professionals. This limits innovation and makes the reuse of APIs more difficult. By way of comparison, in the United States and the United Kingdom, the focus is on generic open APIs (NHS England, 2014; ONC, 2021).

ICT parties in healthcare who want to go along with all developments have to invest a lot of time and money. HP1 implemented a revenue model in which healthcare organisations need to pay per HCIM that they want to exchange. By implementing a cost model based on HCIMs, they want to show healthcare organisations that when they want to exchange more information models, it takes considerably more work due to the need to develop more complex APIs. They are also of the opinion that all information models that are currently being developed are not always necessary. A representative said the following about this:

> *"We also wanted to send a signal to bodies that deal with standardization. Because we saw a proliferation of HCIMs there. Our impression is that standardization did not go well there. Funnily speaking, the universe is made up of fewer elements than what they have come up with in terms of HCIMs."*

In all cases, it emerged that the platform companies contribute or want to contribute to national initiatives that focus on standardization. Not only to make them more doable but also to make them a success. Representatives of HP1 and HP2 mentioned that they strive to contribute their ideas and suggestions as early as possible because then they have the greatest influence on the choices that are made. Parties that want to join the initiative in later stages often see it as a major burden to participate and keep track of all developments. It also becomes increasingly difficult to make adjustments or expansions, the more parties are connected to the initiative. A representative of HP2 also mentioned that it usually revolves around learning together in the development processes of initiatives where they contribute with their own experience, but also learn from others. He mentioned that the disadvantage of this is that you have to deal with all the teething problems, but that it brings the advantage that you get a better sense of the thoughts about certain situations. A representative of HP3 indicated that they try to accelerate developments by participating in all possible pilots, by being involved in working groups and by initiating controlled go-live projects.

A representative of HP1 mentioned that they feel somewhat obliged, as a large supplier, to sit at the table early and think along. They feel a social responsibility to make the initiatives a success. A representative of HP2 mentioned that they share their expertise to help develop initiatives to make a social impact that also benefits their own platform. In cases 1, 2 and 3, the representatives also mentioned that it helps to enter into dialogue with regulatory authorities as these are almost always involved in the initiatives. This increases the chance to talk to the government collectively from different IT suppliers and to receive support and funding. In an interview, a representative of HP2 said the following about the importance of helping in initiatives:

> *"It is an important part of a good relationship. If you never speak to or know those people and never actively contribute, then your right to speak is also a bit more difficult."*

A representative of HP2 also mentioned the following about participating in initiatives:

> *"We would also very much like to act as a guide to provide customers with the most suitable solution, the most effective solution. And it is essential that you also have the latest knowledge as a platform on all fronts. So not only from a technical perspective but also from the context around it, so programs from VWS and other developments that are important in this regard. And that is only possible if you actively participate."*

Even though most initiatives have great ambitions that can have a great positive impact on information exchange in Dutch healthcare, representatives of cases 1, 2 and 4 also mentioned that it is important to continue to develop own solutions. During the interviews, a lot of challenges were mentioned that were associated with the initiatives. Examples are that the initiatives are still largely in their infancy and that it will take a long time before the effects of the initiatives become apparent. It was also mentioned that they are no "holy grail solutions" as most initiatives are solely focused on the Dutch market while all platforms are already active abroad. Besides, a representative of HP4 mentioned that the initiatives sometimes hinder them to offer similar solution themselves as healthcare organisations often prefer to wait for solutions from initiatives:

> *"Sometimes it is very difficult and you really have to have an idea of where it is going and how fast it is going. So sometimes it is difficult because you think "now we have to wait". It could have been better that it was not picked up by VWS, then you could have said: "Well it will not be picked up, then we will do it ourselves"."*

In summary, a wait-and-see attitude on the part of the industry means that the government and payers, like health insurers, take control. To maintain or even regain control over their roadmap, platforms need an interoperability strategy. By developing their own initiatives and taking more control over existing initiatives, the platforms try to avoid unnecessary costs and focus more on their roadmap. As mentioned in the cases, platforms can enter into strategic collaborations or open-source communities in which they work together on specifications and software. An important condition for such collaborations is that all parties involved benefit from the collaboration.

Be (a friend of) the HIS supplier

One of the biggest challenges that was mentioned in all cases is the dependency of platforms on HIS suppliers. Information is exchanged between HISs which means that platforms always have to connect to the HISs of organisations to enable information exchange between them. Direct connections to the database of HISs involves a lot of maintenance and risks. Updates, for example, could potentially cause connections to stop working. As healthcare organisations themselves can decide when they install updates, platforms should continuously test and keep track of the time that each organisation is going to install updates so they can adjust them when this is necessary. HP1, who is also a HIS supplier, therefore assumes that their own HIS customers use their platform for connections with external organisations or applications. For the same reason, HP1 does not support direct connections from other platforms:

> *"So if you create custom connections on the HIS by another party, but separate from [HP1], then there is simply the risk that it will suddenly stop working."*

As HP1 is a HIS supplier itself, they use this to their advantage by deploying the platform as a gateway towards their HIS users. They make sure that the platform is the most affordable, practical or only choice for them to connect to other organisations, applications or initiatives. For example, a representative of HP1 mentioned that it can be very expensive for their customers to start using another platform. HP1's platform is designed as a gateway into the information system which means that when healthcare organisations would use another platform, they may have to pay double costs. If they were to use the other platform without the intervention of HP1's platform, they would again run the risk that the connections would stop working after an update. Finally, the switching costs for changing to other information systems and platforms are very high. Another advantage for HIS suppliers is that the networks of initiatives are often designed in a way that connections have to be made, adjusted and

maintained to the HISs. Within the network, the connections are standardized, but the connections from the HIS to the network are not. When HIS suppliers do not allow, charges high costs or has high requirements for other platforms to offer access to the initiatives, the HIS supplier has the possibility to further strengthen its position by offering the only access to the initiative. This can be seen as a form of vendor lock-in and shows that current Dutch standardization does not always create an open market and level playing field.

All representatives of cases 2, 3, and 4 mentioned that it is important to have good relationships with HIS suppliers. The platforms mainly enter into partnerships with HIS suppliers for which they all have different strategies to do so. HP2 has been around for a long time and has a network of technology partners, including HIS suppliers, with whom they have made agreements about connections to their systems. The partnerships vary as they work closely together with some partners and only have basic, informal agreements with others. HP3, on the other hand, sees the partnerships with HIS suppliers as a necessary evil. As information exchange is essential for the platform to be valuable, HP3 invested, especially in the beginning, in the connections with information systems themselves. Finally, HP4 enters into partnerships with HIS suppliers where they agree to be the preferred partnerships for all connections to the outside world, in exchange for a small percentage of the profit. HP4 chose to use a transaction fee to be able to pay any party they depend on a part of the transaction fee so that everyone benefits from a transaction and is willing to collaborate. In the interview, the respondent compared this model with models in the banking industry, where two banks receive part of a transaction when a customer with a debit card from one bank withdraws money from an ATM of another bank. This model also creates incentives in a way that everyone benefits from a transaction.

Collaborate with other platforms

In all cases was indicated that the platforms work together with other platforms as long as they are complementary. The platforms partner with other platforms because they have the ability to access data from different HISs, because they offer digital support of healthcare processes or because they give access to the networks of national initiatives.

HP2 and HP4 collaborate with HP1 to enable connections with each other′s users. Similarly, HP3 works together with HP1, HP2 or HP4 that already have created communities in which information can be exchanged between organisations. When the system of an organisation is not yet connected to a community, HP2 and HP4 also have the capability to realize a new connection. Vice versa, HP3 offers the other platforms′ customers a digital environment in which healthcare providers can work together and actively use the information. A representative of HP3 mentioned the following about platforms with whom they collaborate:

> *"For us, they are cooperation partners, because what they can do is make data accessible and that is where it usually ends with them. While that is where the game begins with us. We want to have that data accessible. Whether [HP2] does that, or [HP1] does that, it doesn't even matter that much to us. They can do that, I think that's all fine, as long as it does happen."*

The representative also mentioned that it can be a challenge to ensure that suppliers provide access to their systems. HIS suppliers sometimes do not disclose their systems to strengthen their position. Since access to the information systems is of great added value for many organisations, these platforms have ensured that they benefit from it with their business model:

> *"And often those parties are of course aimed at protecting their own interests and that is why they do not unlock their systems, well then they do not become interoperable."*

Representatives from HP2 mentioned that it was also very difficult to access the HISs of HP1 but that the introduction of HP1′s platform did actually made it easier to access the systems. However, according to HP3′s representative, the high integration costs charged by other platforms often comes at the expense of interoperability between healthcare organisations. The essence of HP3 is for information to flow between healthcare organisations. This should happen without the intervention of companies who deliberately shield their systems for information exchange with external systems with the goal to make money from it.

A representative of HP1 mentioned that other systems or platforms have to pay for every new connection to the platform as they have to put in the effort to connect, manage and maintain them. He mentioned about the partnerships with other platforms that these are based on a joint effort in which HP1 arranges the connections to HP1's platform and where the integrators' platform arranges the connections to their platform. The representative of HP1 mentioned that they only invest their time in making the integrations with HISs through other platforms when their own HIS customers are willing to invest and when it adds significant value to them. Moreover, a prerequisite is that the same technical standards are used by the other platform to ensure that time investments do not exceed the added value.

Service integration

HP2's platform consists of a module in which they offer multiple collaboration applications and HP3 offers an environment for providers to collaborate. Different from HP1 and HP4, providers can exchange information and actively work together on the platforms themselves. This is also characterized as the "service integration" function. See figure 6 for the corresponding data structure for this function.

According to a representative of HP3, users, data and content are the three value drivers behind the platform and the service integration function. First of all, the platform needs users, which consists of both patients and healthcare providers. Secondly, the platform needs the data to flow between these users. And finally, the platform needs content that is valuable for the healthcare process.

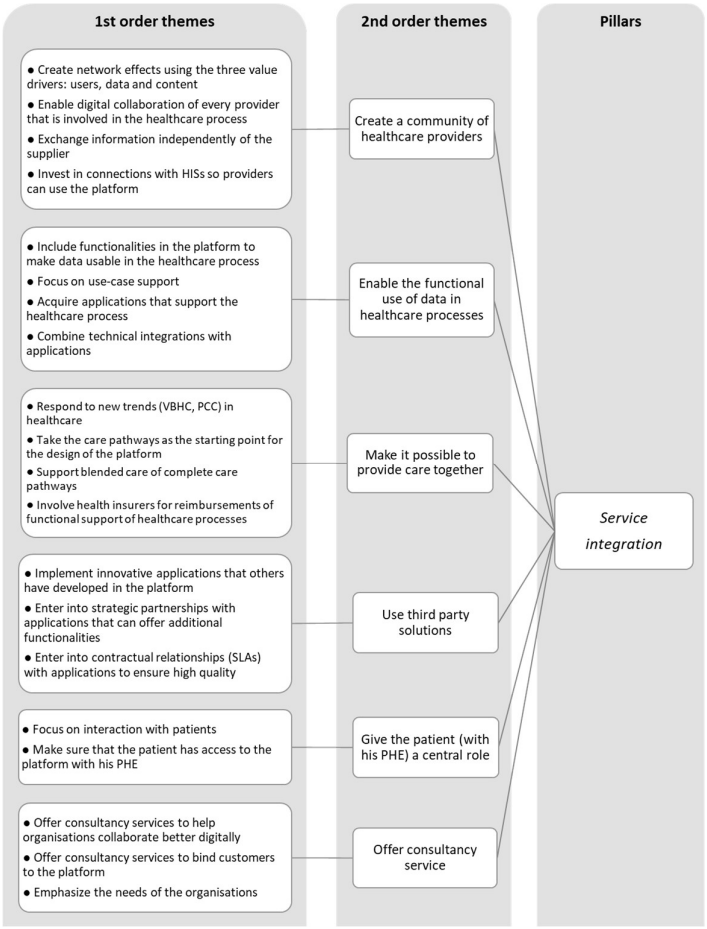

Figure 6: Data structure for the "service integration" pillar

Create a community of healthcare providers

Both HP2 and HP3 are supplier-independent to enable every healthcare provider and organisation the possibility to access the platform. HP2's community consists of all different types of healthcare organisations, from small independent practices to large academic hospitals. This also creates network effects, as the platform is often attractive for organisations that want to collaborate with a lot of different

organisations. HP3, on the other hand, connects all healthcare providers that are involved in the care of a patient together in a digital environment. As the network of a patient can consist of both a healthcare provider working in a big university medical centre and a therapist from a small practice, the platform has to provide access to all kinds of providers. This means that HP3 gives every healthcare providers the possibility to access the platform. All providers with an AGB code (General Data Management-code), which is a code with which healthcare providers are recognized, can make use of the platform. Important to note is that when the platform connects to a big university medical centre, then many more care providers can be reached at once than if the platform connects to a small practice. Big hospitals or university medical centres can therefore be characterized as marquee buyers.

Besides, when HP3 was founded, it was decided to opt for a cooperative as the legal form. The purpose of a cooperative is to realize the economic, cultural and social needs of the organisation′s members and its surrounding community. In the case of HP3, this means that a positive balance will be used to reinvest in innovation, strengthen reserves or lower membership costs. Especially when organisations are unable to pay for expensive one-off and structural integration costs of commercial ICT suppliers, becoming a member of HP3 can bring benefits. Integrations through HP3 will more likely result in lower costs because of their non-profit cooperative model and the possibility to divide the structural costs among the members. This is extra beneficial when incentives schemes exist that reimburse the one-off costs for integrations.

Enable the functional use of data in healthcare processes

Both HP2 and HP3 enable the functional use of data in healthcare processes. HP2 does this by combining technical integrations with applications in which healthcare providers can collaborate and that support the care process. In the interviews, the representatives of HP2 indicated that information exchange between healthcare organisations is more and more realized and that information exchange alone is no longer enough to support a care process. The trend in healthcare is that the degree of organisation in collaborations increases every year. In order to move with the trend, the essence of the platform is to shift from the support of information exchange to the support of collaboration between healthcare organisations. To do so, they combine their solutions for technical integrations with collaboration applications. They have already taken over several parties that have developed promising or successful applications and they expect to continue to do so in the future. HP2 uses their experience in facilitating technical integrations to integrate the applications, which are often extra applications on top of the primary information system. By combining their services, they proactively create demand for healthcare organisations and providers to start using more applications.

A lot of platforms only enable technical information exchange between organisations. However, according to the founder of HP3, this is not enough to support the care process. He mentioned multiple times that it is only valuable to exchange information when the information can truly be used in a care process. To be able to do so, it is important to connect providers that are involved in the same care pathways to each other in one environment. In this way, information that is needed to share only reaches relevant healthcare providers and an information overload for other providers is prevented. The next step is to make the information from the various care providers in the network clear and usable for everyone, for example through dashboards. In this way, information that is exchanged between providers can be used directly to support the care process.

Enable blended care of complete healthcare processes

HP3′s ultimate goal is to enable blended care of complete healthcare processes. By taking care pathways as the starting point for the design of the platform, HP3 responds to new trends in healthcare, like Value-Based Healthcare (VBHC) and Patient-Centred Care (PCC)[1]. Besides, by connecting all healthcare providers that are involved in the healthcare process of a patient with the patient himself, patients can take more control over their own process. They can, for example, more easily give consent to all healthcare providers who may have access to their information.

[1] VBHC and PCC place the individual patient at the centre of the delivery of care and redirects activities so that the right job is performed effectively by the right person at the right time (Kitson et al., 2013; Pelzang, 2010). It has shown to improve continuity of care and integration of providers collaborating on behalf of their patients (Porter, 2010; Porter & Lee, 2013).

HP3 divided their platform into different modules for different care pathways, like care for chronic pain patients and birth care. HP2, on the other hand, supports and has recently taken over applications in which healthcare providers can work and treat together. In this way, the platforms set up a kind of joint ventures or virtual healthcare organisations that healthcare providers can probably also start using to invoice jointly in the future.

However, in cases 2 and 3 some challenges were mentioned that stand in the way of making blended care of complete care pathways possible. The biggest challenge is the current decentral organisation and financing of care in silos, where care pathways do not remain within one silo but usually involve multiple silos. This challenge can be extra disadvantageous because of the low innovative capability in healthcare. Healthcare organisations are slow to implement new innovations. According to a representative of HP3, the reasons for this are that they often have a lack of knowledge and expertise about the innovations and that they are reluctant to invest on a large scale in them. He mentioned the following about difficult to change behaviour in healthcare:

> *"If you do what you do now and you waste a lot of time on inefficient processes, you never make time for structural changes. In healthcare, they mainly suffer from very Pavlovian behaviour. They do what they do, but it makes it difficult for them to move to really think: "Yes, but what if we do things very differently"."*

Regarding the reimbursements of blended care, a representative of HP3 mentioned that they involve health insurers. The relationship between who buys, who pays and who benefits is often unclear in healthcare. Indirect payers, like healthcare insurers, often pay for applications that are used to digitally support and improve healthcare processes. The representative of HP3 mentioned that health insurers usually not pay for technology, but instead, pay for solving care problems and for organising care more efficiently. HP3 now charges healthcare organisations costs per patient for the digital support of certain care processes. Thereafter, health insurers reimburse these costs. Ideally, healthcare insurers directly finance blended care as part of the total treatment program.

Use third party solutions

For HP3, the presence of users and the possibility to exchange data are the first goals. The next step is focused on adding content to the platform. By content, all functionalities in the form of applications or modules are meant. The platform creates or adds content wherever it can add value to its users or future users for the support of care processes. This will also result in network effects, because the more functionalities, the more interesting the platform becomes for providers. Usually, HP3 comes into contact with healthcare professionals or other knowledge partners who have developed or are working towards digital functionalities for solving problems in healthcare processes:

> *"So we use knowledge and experience from the field. 9 out of 10 times we come across people who are working with innovative applications to solve problems in healthcare, through our network, through contacts. And then we can start building solutions."*

As mentioned before, HP2 acquires applications that can be valuable to their customers. As HP2 is an independent platform with the strength to connect *"every system or service in healthcare"*, they also still facilitate connections with applications that are not included in their product offering. When platforms open up to third-party applications and make smart use of external capabilities to offer innovation to their customers, they fulfil the "service innovation" function. However, HP2 often has contractual relationships with third-party applications in which applications are required to meet the minimum technical conditions that are used in healthcare. Besides, the focus of HP2 is on acquiring customers for their own applications. A representative of HP2 mentioned the following about this:

> *"We never want our customers to feel that there is vendor lock-in. They determine because it depends on their pace. Sure, I'm going to love it when a lot of our customers have all of our applications. That is of course the ultimate goal from our reasoning point of view. But the customer has to want that himself and we have to make sure that they are of such a good quality that they would actually be stupid to not have them."*

Give the patient (with his PHE) a central role

The founder of HP3 indicated that most healthcare platforms are mainly focused on interactions between healthcare providers themselves, and that little to no attention is paid to interaction with patients. It is often the case that only limited data is made available for patients via portals or PHEs. HP3 does this differently by giving patients, with their PHE, a central role in their platform. HP2, on the other hand, enables connections with PHEs and gives patients access to eHealth.

In addition to its platform which is intended for healthcare providers, HP3 also offers their own PHE. The two environments are closely related and can benefit from each other as the direct connections of the environments enable healthcare providers to exchange information and to actively collaborate with patients. As soon as more providers are connected to the platform, it also becomes more interesting for patients to use the PHE since they can access information and control their care process. Vice versa, it is also the case that when more patients use the PHE, it becomes more interesting for the providers as they have more possibilities to support healthcare processes through eHealth.

Offer consultancy services

Representatives of HP2 specifically mentioned that they offer services as part of their competitive strategy. Especially because healthcare platforms often exhibit high levels of technological and use complexity, healthcare organisations often do not know which platform or technique best support their organisation. As an increasing amount of standards, infrastructures, trust frameworks, laws, regulations and norms need to be taken into account, HP2 wants to unburden healthcare organisations by offering consultancy services. Besides, opting for a healthcare platform involves significant transition costs from the existing technology or platform to the new one. Consultancy services can help to minimize the potential hurdle to start using the platform. HP2 does this by providing easy access to technical support, implementation services and customization. A representative of HP2 stated:

> *"Technology is often used as an excuse for not cooperating. And at that level, we want to advise and help because we think that technology is not the problem. So we want to discuss with that customer what is the right level, which use case do you want to tackle, what is the maturity of your collaboration. And what fits best with that."*

Furthermore, for existing customers, the services can reduce the risk of adopting a new platform. A representative of HP2 mentioned that they offer extensive services to around 20 per cent of their customers who do not have enough knowledge about ICT themselves. Offering consultancy services pays off because these customers often purchase more. As HP2 has a broad product offering that is constantly being supplemented and innovated, they can bind customers to their platform for a long period of time. In order to offer high-quality consultancy services that emphasize the needs of their customers, HP2 needs to have the latest knowledge of all relevant developments in the field of health-ICT. As mentioned before, they do this by actively participate in all kinds of national initiatives.

Service innovation

Cases 1 and 4 differ from the other cases as they focus on external capabilities to offer innovation to healthcare organisations. They use open platform boundary resources to enable third party applications to expand their market by connecting to the platform. See figure 7 for the data structure of the "service innovation" pillar.

A lot of applications are interested to connect to the platform of HP1 because of the indirect network effects. Applications can reach a large market of hospitals through the platform as the majority of hospitals in the Netherlands uses HP1's HIS software and is connected to the platform. Vice versa, the platform also generated indirect network effects for their HIS users. The more connections with healthcare applications, the more attractive it becomes for organisations to use the HIS software in combination with HP1's platform.

HP4 also tries to create indirect network effects for both the application side and the healthcare organisation side of the platform. HP4 enters into partnership with HIS suppliers to be able to offer their customers applications. This makes the platform interesting for healthcare organisations as they get quick and free access to applications in this way. Applications, on the other hand, are interested in the

platform because two HIS suppliers are already connected which provide them potential access to all their customers. In an interview, a respondent mentioned that network effects have to ensure that the platform will grow exponentially. According to the respondent, they already created network effects by partnering with two of the largest HIS suppliers worldwide and the first applications:

> *"Actually, it's a kind of self-reinforcing wheel, so we connected two of them and then it means we can go to all those hospitals like: "Guys, we can connect applications now". And the applications already find it interesting that we have two HISs. So the more HISs we have, the more interesting it becomes for applications. So it's kind of self-reinforcing."*

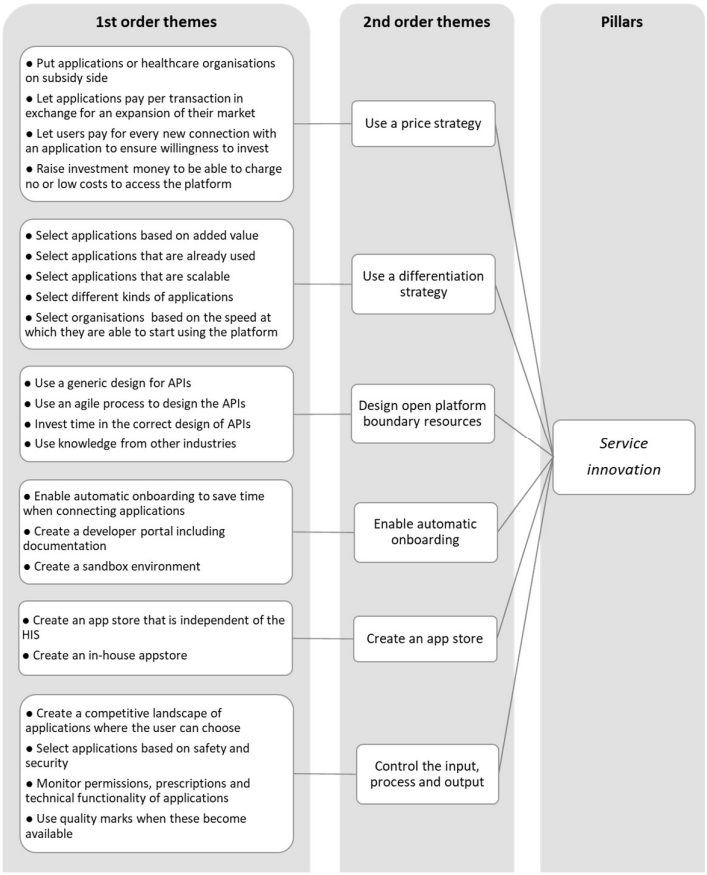

Figure 7: Data structure for the "service innovation" pillar

Use a price strategy

Similar to connections to other organisations for information exchange, HP1 uses a revenue model in which healthcare organisations pay for every new connection to an application. In this way, they ensure that customers are willing to invest and that they only invest time in integrations with applications that add significant value. As mentioned before, they also let these costs depend on the complexity of the information exchange. Besides, when organisations chose to connect an app, the app owner usually also charges costs in the form of subscriptions. App owners themselves do not owe any costs to the platform. The platform also does not plan to charge them for this in the near future.

HP4 uses a revenue model in which applications pay costs that depend on the extent to which the application is used by users of the platform. The model is aimed at a transaction fee which means that application owners only have to pay when their app is actually used by users of the platform. The fact that HP4 does not charge any initial integration costs makes it feasible for all kinds of applications to connect. This is especially the case for apps that can profit from the new market they can reach through the platform, such as foreign apps that want to enter the Dutch market. But also small applications have a chance to be successful in this way, for example, an app that focuses on a rare disease.

The biggest challenge for HP4 is to convince applications to go along with the revenue model. The reason for this is probably related to the fact that there are some companies in healthcare that also

charge a transaction fee, but which brought a bad experience. These companies slowly but surely allowed the fee to increase substantially so that it has now become almost unaffordable to use the platform. However, according to a representative of HP4, the focus of HP4 is not to generate as much profit per transaction as possible, but to increase the number of transactions and to lower the transaction fee over time. They also make agreements with their users in which is stated that the transaction fee will not rise for a certain amount of time and that there is always the possibility to leave the platform. To be able to maintain the price strategy in which the platform wants to offer free integrations and maintenance and a low transaction fee, HP4 has collected investment money.

The new revenue model of HP4 can also mean for health insurers that they no longer have to pay the integration costs as long as the applications connect via HP4′s platform to healthcare organisations. In this way, the health insurers can play a big role in convincing organisations to choose HP4 instead of another platform that charges high integrations costs. A representative of HP4 mentioned the following about their collaboration with healthcare insurers:

> *"We can also go into that breach together by saying; "start thinking in a different way!". A health insurer can also offer some sort of guarantee like; "we guarantee the costs, that it will really be lower and will never be higher, otherwise we will take care of it". … So I think we both want the same thing, which is a system overhaul and cheaper care."*

In addition, HP4′s price strategy means for healthcare organisations that they do not have to pay anything when they want to connect to the platform. They just need to make a small time investment by deploying some employees to help realize the connection with the platform. Compared to the other platforms that charge high costs for integrations, HP4 makes itself especially attractive for smaller organisations as they can not afford the connection costs of the other platforms. HP4 makes it possible for all kinds of organisations to start using a platform.

Use a differentiation strategy

The downside of HP4′s revenue model is that HP4 has to invest a lot of money now which they will only recoup in the long run and with the condition that they create a lot of transactions. This only works when a lot of organisations on the one side, and applications on the other side, connect to the platform. As a lot of application are interested to connect, but HP4 has not yet enough capacity to connect them all, the platform needs to make strategic decisions on the selection of applications to enhance network effects as much as possible. For HP4, the most important criterium is the scalability of the application. The application should be willing to innovate and invest in growth, preferably international. They should also be using APIs to be able to switch quickly and so that they do not need a new implementation process for every hospital that wants to connect. Similar to HP4, HP1 is also still in a growth phase in which its capacity to connect applications is limited. As they attach great importance to the added value of the applications to their users, they make trade-offs between the amount of time they can invest in a connection to an app and the added value of the app to their customers. For this reason, the platform initially mainly selected applications that were already successfully in use or that were in the pipeline to be used successfully.

Besides the selection of applications, HP4 also makes strategic decisions related to the selection of organisations. For the selection of healthcare organisations, the most important criterium is speed. As HP4 needs to invest a lot of money in integrations before it can start making money on integrations, its burn rate is very high. As integrations are reused, the more organisations and applications connect, the more the integrations are used. As a result, the relative costs decrease and the total turnover from transaction fees increases. In other words, the number of connected organisations has to grow as soon as possible to absorb the high costs of the integrations. HP4, therefore, focuses on organisations that have the use cases, time and people to quickly make the integration with the platform.

Similar to all other platforms, HP1 and HP4 also suffer from the low innovative capability in healthcare. A representative of HP4 mentioned that every healthcare organisation is interested in the business model of HP4 because they realise that they are not able to buy and maintain increasingly more connections to other systems and applications themselves. However, healthcare organisations are often too busy or reluctant to realize the integrations with a platform as it often results in a different way of working. On top of that, in the last year, hospitals were very busy with the COVID-19 pandemic which

meant that there was even less time left to invest on a large scale in innovations. As a result, managers are often looking for immediate, short-term solutions. They often choose for a single connection that is subsidized in an incentive scheme as opposed to the use of a scalable platform that can be cheaply deployed for all future connections. According to one of the founders of HP4, one of the biggest challenges is to convince healthcare organisations to start using a platform instead of buying and maintaining point-to-point solutions every time they need an integration to another system or application. HP4 tries to convince organisations by investing time in giving presentations and involving organisations in technical sessions:

> *"There is often a need for one connection, so one special use case: "I need that app or I want to collaborate with that healthcare organisation". Then you are going to have one thing built and for that, you can put a consultant there and it may cost 30000 euros. We still have to generate and explain our offer to those hospitals like: "Don't just make that one connection for 30000, but make sure that some man-hours are released internally to do that integration and then you have a platform to which you can connect all those things, without having extra costs and without having to pay that integration fee every time"."*

Design open platform boundary resources

Both HP1 and HP4 offer open APIs by which applications can connect to their network of HISs. Open APIs are those APIs that have been exposed to enable other systems to interact with the platform. As they are using one set of APIs, applications that connect to the platform can directly be accessed by all connected healthcare organisations. Both platforms chose to use a generic design to ensure that the APIs are widely applicable and usable for applications.

HP4 translates all data from the different systems to one uniform API, largely based on FHIR. They chose the FHIR-standard since it is compatible with the Dutch HCIMs. Even though the Dutch HCIMs are still in their infancy, they form the basis for the standardization of healthcare information in the Netherlands. From all systems they disclose, HP4 follows the structure of the information and the content of the HCIMs as much as possible. Moreover, HP4 also continues to support older versions of technical standards and custom protocols, like REST, SOAP and SQL to support even more different types of information exchange for which no big investments are needed.

At this moment, both HP1 and HP4 are in a discovery process into the best way to organise connections to third party applications. A representative of HP4 mentioned that they hire ICT experts from the fintech industry which give them an edge in the quality of the technology they develop. In both cases, representatives mentioned that it is important to invest time in the correct design of the boundary resources. They want to test early and get feedback in order to arrive at the best design. They have chosen to start in an agile process instead of organising the APIs and the developer portal down to the last detail. A representative of HP1 mentioned the following:

> *"It is more the logical growth model that you do not start to set up a developer portal behind the drawing board and that you immediately make everything plug-and-play. Instead, we simply needed the time to align with all kinds of parties and to test our ideas. So it is very logical to do this more manually and in all kinds of conversations and not to suddenly set up a completely automatic sandbox environment "out of the blue"."*

Enable automatic onboarding

Both HP1 and HP2 have the goal to enable automatic onboarding to save time in the process of connecting applications. HP1 has its own website for developers with a developer portal on which all available documents about the interface specifications are shared. As no sandbox, or testing environment, is yet available, HP1 is forced to support the developers with testing and connecting to the platform. This can take a long time, especially when the developer has not developed exactly according to the documentation. It is a necessity for the platform to make this process more efficient, more convenient and easier. To enable (more) automatic onboarding, they want to provide developers with all necessary documentation, developer support and a sandbox environment, in which developers can test and experiment with their code.

Similarly, HP4 provides application owners with the technical foundation and building blocks to connect applications in a fast, simple, and secure way. They do this by sharing all documentation of their APIs on their website. Applications who want to use healthcare data, register themselves on the platform. The healthcare organisations control which data is made available and they can change this at any time. A representative of HP4 mentioned the following about automatic onboarding on their platform:

> *"Ultimately, we want to automate the entire process. So that applications can already integrate themselves via that sandbox environment. That is also possible with an App Store and Android. You can register yourself, you can make the technical connection and then eventually a check will take place with us, but they can do all the work before they even have a customer at all."*

Once connected, HP4 offers applications a market of connected healthcare organisations. In this way, the platform removes the integration barrier in the sales process. HP4 helps applications to scale up to new organisations by taking care of the development and maintenance of integration in turn for a small fee per transaction. In an interview, a representative compared this model with the ability to download apps on every mobile phone. By taking away the problems of integrations, the application owners can focus on product development. A big challenge for healthcare platforms is the low innovative capability of healthcare applications, like the fact that they are often not able to scale with the platform. They are often designed for a specific context or, in contrast, they have very general functions. Others cannot handle the documentation and are unable to use APIs to connect to the platform.

Create an app store

Both HP1 and HP4 have created an app store in which they offer applications with whom they have a connection. HP1 has an in-house app store that consists of all applications that are connected to the platform and which can be integrated into the HIS of connected organisations. Providers within these organisations can choose and start using one or multiple applications that are available in the app store.

In contrast, HP4 offers an independent app store. Healthcare organisations are offered to connect to the platform for free. Once connected to the platform, they can select, from the pool of connected applications, the applications to which they want to connect. The connections to these applications are independent of the information system the organisations use. This means that the organisation can continue to use the platform when they switch to another HIS. This removes the barrier to connect applications since these connections can be maintained more easily and do not create any more dependence on the HIS supplier. The use of the platform can also ensure that organisations do not have to make an expensive switch to a new HIS supplier as the applications that the platform offers can bring new functionalities that may be missing in their current information system.

Control the input, process and output

Both HP1 and HP4 have determined that it is the responsibility of organisations to check the quality of third party applications with whom they want to connect. The reason for this is that they simply do not have substantive knowledge about healthcare provision itself. For HP1, it applies that when a healthcare organisation wants to make use of an application, they have to prepare a processing agreement to make sure they comply with all relevant laws and regulations and to agree on the permissions of the app. After this, the application is considered trusted and will appear in the in-house app store of the organisation. Healthcare providers within the organisation now have the possibility to prescribe apps to their patients. However, once connected, HP1 gives applications a lot of freedom for further developments whereby it remains the responsibility of the user to keep checking the content. Additionally, HP1 does monitor the behaviour of organisations and applications in the app store by checking whether organisations only use applications for which they paid for and whether applications adhere to the agreed permissions and app prescriptions to patients. In this way, HP1 checks for fraudulent behaviour, for example when applications start to retrieve data from organisations that did not permit them to do so.

Besides, apart from some minimal requirements regarding safety and security, HP4 plans to give every application the possibility to connect. Their goal is to create a competitive environment in which users can decide which selection of available apps on the platform they want to use. HP4 only monitors the technical functionalities of applications and, similar to HP1, it is the responsibility of the

user which app they use and to check whether the app delivers a high content quality and has the correct certifications. At this moment, no quality marks for applications exist in the Netherlands. A representative of HP4 describes the current situation as follows:

> *"Now it is the case that when a new app comes along, a new entrepreneur who has made the app goes by every hospital like: "Look how great". And then each hospital must individually assess whether they find it interesting and whether it is safe. Well, that's just a waste of time."*

The representative also mentioned that health insurers in the Netherlands are now working towards a quality mark. The insurers realized that when every organisation has to make their own decisions, the risk increases that they will not always make the correct decisions. HP4 plans to work together with health insurers to jointly develop the quality mark. Although they are not able to check the content of an app, they can help to check the quality of the technology that applications use, like the width of the connection, the safety and the type of standards. The plan is that health insurers will take responsibility for assessing the content of applications and HP4 will conduct technical assessments to judge whether the applications are technically sound. Both HP1 and HP4 see the advantages of quality marks as they can help to clarify the extent to which applications can reduce healthcare costs, provide better care and are safe to use. This may help healthcare organisations to lower the barrier to start using applications.

Grounded theory

Following the Gioia method, the model in figure 8 was developed, making the dynamic relationships among the second-order concepts and pillars more transparent (Gioia et al., 2013). Each block consists of a pillar that is again divided into the success factors related to platform design and governance and environmental dynamics. The former is related to the decision making and the way platforms and their complementary set of modules are constructed (Tiwana et al., 2010). As can be seen in figure 8, an example from the information pillar is for platforms to offer their own SaaS solutions for different types of information exchange. Healthcare platforms usually divide these solutions into separate modules to be able to adjust these modules independently and respond to future, unforeseen changes more easily. Within healthcare, this is relevant since different ever-changing requirements and trust frameworks belong to different types of information exchange. Regarding the integration pillar, platform design and governance are related to modules with functionalities that enable providers to collaborate and provide care together. Finally, for the service innovation pillar, this is especially related to the openness of the platform towards third-party applications.

Environmental dynamics are mainly related to developments of complementary and substitutive technologies and the influence exerted by parties outside the platform′s ecosystem. For the information pillar, this is for example related to the dependency on the government and the extent to which platforms involve themselves in (inter)national standardization initiatives. For the other pillars, this is especially related to complementors and competitors. The environmental fit is related to the way environmental dynamics affect and are affected by the endogenous platform design and governance. For example, within the information pillar, the regulated market and decisions of HIS supplier can have a huge effect on the information exchange solutions offered by the healthcare platform. For the integration pillar, developments within PHEs are closely related to developments within healthcare platforms and vice versa, and for the innovation pillar, choices made by third-party applications can affect the way platforms need to set up their boundary resources and control mechanisms. Besides, high switching costs and price and differentiation strategies of competitors can affect the way they have to design their own pricing and differentiation strategy.

As enabling information exchange is the starting point for every healthcare platform to become successful, the corresponding block is positioned on the left side of the model. Once a platform enables information exchange, they can either focus on service integration, service innovation, or in exceptional cases on both. Interestingly, the service integration and service innovation pillars are often interrelated. HP3 offers a platform for providers to collaborate, where HP4 sees platforms like HP3 as applications that can connect to their platform to broaden their market.

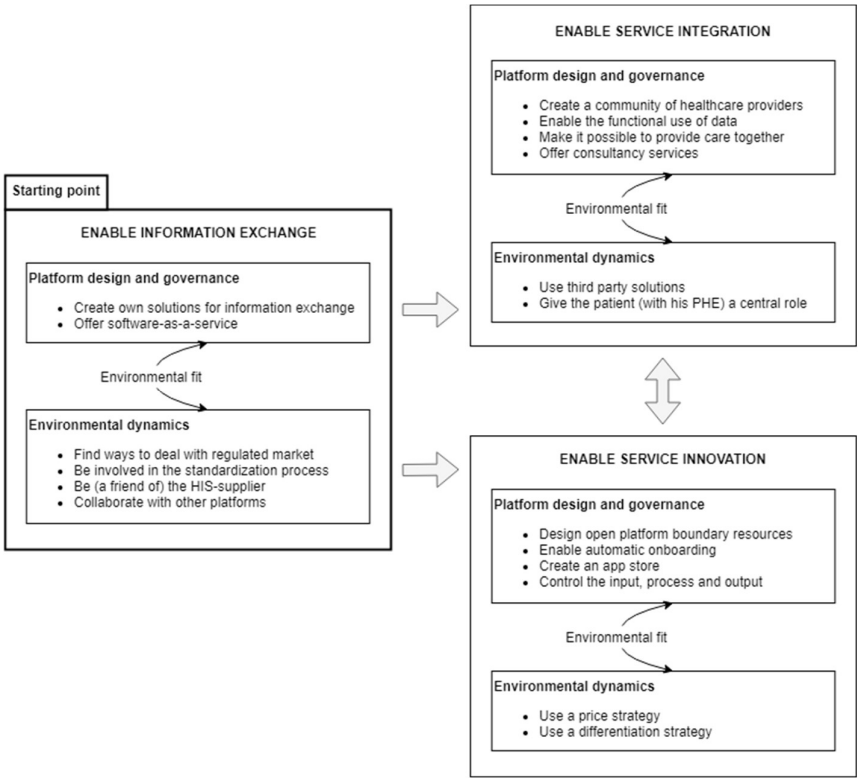

Figure 8: Model showing the relationships between the pillars and success factors of healthcare platforms

As information exchange is more and more arranged, it is expected that the functions of the platforms will differentiate more in the future in which platforms like HP3 are likely to focus more on service integration by emphasising the functionalities within their platforms. In contrast, platforms like HP4 are likely to focus more on service innovation by offering integrations between systems, platforms and third-party applications. HP1, on the other hand, which owns a platform in addition to their HIS, may shift focus to their HIS when other independent platforms, with a sole focus on their platform, become more attractive as a result of better strategies. Besides, due to increasing interference of the government, HIS suppliers like HP1 have to open up their systems for connections to the outside world, which undermines parts of their current strategy for information exchange. Finally, HP2′s strength is that they own both integration solutions and applications and that they can profit from their large community. New platform business models, like HP4′s, may force them to come up with new strategies.

Discussion

Based on the results from the multiple case study, the research question could be answered by compiling an overview of the success factors to achieve Dutch healthcare platforms for information, integration and innovation (see table 5). The success factors consist of practices that focus on key design and governance and responses to environmental dynamics. In addition, the model in figure 8 was developed to make the dynamic relationships among the factors and functions more transparent.

Table 5: Success factors per case

Information	Cases	Integration	Cases	Innovation	Cases
Offer software-as-a-service	1,2,4	Create a community of healthcare providers	2,3	Use a price strategy	4
Create own solutions for information exchange	1-4	Enable the functional use of data	2,3	Use a differentiation strategy	1,4
Implement strategies to deal with the regulated market	1-4	Make it possible to provide care together	2,3	Create an app store	1,4
Be involved in the standardization process	1-4	Use third party solutions	2,3	Design open platform boundary resources	1,4
Be (a friend of) the HIS supplier	1-4	Give the patient (with his PHE) a central role	3	Enable automatic onboarding	1,4
Collaborate with other platforms	1-4	Offer consultancy service	2	Control the input, process and output	1,4

Key findings and link to the literature

For the information exchange pillar, it became clear that all platforms have to enable information exchange before they are able to offer additional functionalities. The results show that platforms primarily have the goal to unburden healthcare organisations by facilitating information exchange with outside parties and by offering SaaS. They develop their own solutions for information exchange, as there are still no national networks for the exchange of all different types of information. From the cases can also be concluded that healthcare platforms need to take control over the standardization process in the Netherlands and need their own interoperability strategy to avoid unnecessary costs and dependency on the government. They can do this by entering into strategic public-private partnerships, by helping to develop initiatives, by being a friend of the HIS supplier and by collaborating with other platforms. As the platforms experience little competition, strategic collaborations or open source communities are often beneficial for all parties. Important to note is that everyone has to benefit from collaborating, for example, by implementing a strategy that is focussed on sharing the profits among all involved parties, as was also found in other research (Van Alstyne et al., 2016b). Besides, since some regulation within the healthcare industry is inevitable, it is important for platforms to maintain a good relationship with the government and to use incentive schemes, laws and regulations to their advantage. Similar to what is mentioned in previous research, timing is crucial for platforms to create network effects (Cusumano et al., 2019; Yoffie et al., 2019). The results of this study show that healthcare platforms need to emphasize the correct timing to design technical architectures and select standards, taking into account developments from the government, to be able to generate network effects and make money by profiting from subsidies.

Regarding service integration, the cross-case analysis showed that HP2 and HP3 both offer digital functionalities that support healthcare processes and facilitate healthcare providers from different organisations to collaborate. HP2 uses a combination of strategic proprietary product development and a selective international buy-and-build strategy. The company combines its own technical capabilities to realize information exchange between healthcare organisations with selectively acquired applications, which enables providers within organisations to use information in their healthcare processes. As also mentioned in previous research, complement absorption can result in efficiency gains by users as well as economies of scope for the platform (Eisenmann et al., 2009). Integrated designs may yield quality advantages through simplification of interfaces and platforms have the opportunity to sell a more valuable bundle. As HP2 does not open up to application developers and mainly serves end-users, it is important to note that the platform can be considered as one-sided (Tiwana, 2013). Similarly, HP3 does

also not provide open interfaces for application developers at this moment. However, they do offer an environment in which providers can actively work together with each other and with patients through HP3′s PHE. In this case, the providers and patients can be seen as two sides, which also experience indirect network effects. Moreover, other than the other platforms, HP3 is not proprietary to a single firm but shared by multiple owners who all have decision rights (Eisenmann et al., 2006; Hein et al., 2016). The platform has a joint venture model in which several firms jointly sponsor the platform but a single company serves as its provider (Eisenmann et al., 2009). Sharing the platform has benefits as the total market size expands and competition decreases. Besides, especially HP3 shows that it is important to create network effects using three value drivers: users, data and content. This is similar to the way transaction platforms from other industries create network effects (Cusumano et al., 2019). Examples are Facebook and Instagram that match users and user groups in which the value for a user increases with the number of users in a user group. Additional features on the platforms themselves also increase the value for their users. The latter is similar to healthcare platforms offering eHealth functionalities (Hein et al., 2016). HP3 included functionalities on their platform to make data usable in the healthcare process and to enable healthcare providers to provide blended care. To do so, they took the care pathways as the starting point for the design of the platform and they tried to give the patient, with his PHE, a central role to make it possible for them to actively engage in their healthcare process. Especially the case of HP3 shows the added value to respond to new trends in healthcare, like VBHC and PCC (Kitson et al., 2013; Porter, 2010; Porter & Lee, 2013).

For the service innovation pillar, where HP1 and HP4 mainly focus on, it became clear that it is important to engage with the platform ecosystem and wider environment. In contrast to HP3, they are propriety platforms, where a single firm plays both the sponsor and provider role (Eisenmann et al., 2009). Similar to platforms from other industries, like Amazon, the suppliers make their open APIs available (Moore & Tambini, 2018). The APIs are proprietary but their documentation is completely available and free of charge. For the open APIs to be successful, the suppliers offer or plan to offer version control, support and a sandbox environment to enable automatic onboarding of applications. These are characteristics similar to open and transparent innovation platforms as described in existing platform literature (Bonchek & Choudary, 2013; Gawer, 2020; Ghazawneh & Henfridsson, 2013). Furthermore, healthcare platforms have shown to maintain necessary input, process and output controls, like security checks and monitoring. However, their application review processes are mild as they want to create a competitive environment in which users themselves need to check the quality of the applications. This strategy is similar to the "apps market competition" strategy which has shown in previous research to have positive and significant effects on platform market share and performance (Cennamo & Santalo, 2013). Comparing the input control of healthcare platforms with the Google Play Store and the Apple App Store, healthcare platforms are more similar to Google as they are less strict and only execute automated reviews. The comparison of the app stores in other research showed that no or limited input control causes a greater variety of input but entails a decreased quality (Hein et al., 2016). For organisations using healthcare platforms, the limited input control may translate into a burden and lack of trust as the platform has an increased risk of offering low-quality applications. Especially in the case of platforms in healthcare, the negative effects of low-quality applications may have a greater impact since they can influence the quality and safety of healthcare delivery. As one of the most common mistakes of platforms is the failure to develop trust with users and partners, this may lead to problems in the future (Cusumano et al., 2019; Yoffie et al., 2019). However, representatives indicated that the arrival of quality marks may enhance trust as it can help organisations to make better decisions regarding the quality of applications. The final factors regarding the service innovation function are the use of price and differentiation strategies to enhance indirect network effects. HP4, for example, raised investment capital to be able to charge no costs for integrations and maintenance and low transaction costs for applications. The subsidies create indirect network effects that can grow the customer base. This also seems necessary as the results show that there are high switching costs for organisations to start using another platform with similar functions (Eisenmann et al., 2006; Gawer & Cusumano, 2014).

As shown, healthcare platforms share distinctive economic mechanisms with platforms from other industries. However, the cases in this study also highlighted a few differences. Firstly, three of the four cases are incumbent initiatives, where HP1 and HP2 are vendor-led and HP3 is provider-led. This is in contrast to, for example, new market entry platforms aiming at changing existing markets, like technology start-ups Uber and Airbnb (de Reuver et al., 2018; Tiwana, 2013). Secondly, in line with the

incumbent′s role, the strategic priority has been set on improving the interoperability of existing systems, over or as the basis for innovation. The platforms in this study collaborate and form alliances with other platforms and HIS suppliers to set up initiatives and agree on open standards to be able to exchange information between different parties in healthcare. Besides, especially HP1, HP2 and HP3, include functionalities in which the goal is mostly to integrate into existing healthcare processes and care pathways in which less emphasis is given to stand-alone apps. The choice of standards and the engagement with the wider platform community suggest a more inclusive approach, in contrast to strategies of market dominance and monopolization attributed to, for instance, Google and Facebook (Cennamo & Santalo, 2013; Cusumano et al., 2019; Eisenmann et al., 2006).

Moreover, despite the platforms showing dynamic development, HP1, HP2 and HP3 do not show any of drivers of massive scaling, like extensive venture capital as the basis for massive investment and compensation for initial losses or extensive indirect network effects, typically combined with substantial subsidies for one user group (Rochet & Tirole, 2003). As a result, it is expected that healthcare platforms scale more slowly. Also, the low innovative capability in healthcare, due to the complexity of the industry and the regulatory constraints, results in the transformation that the platform can bring about is a fairly slow process. There are a lot of different stakeholders that all have their own interests. There are various associations with different compositions that represent the interests of healthcare organisations by setting up initiatives, advising them or even starting to offer their own solutions for information exchange and innovation. Additionally, within organisations, there is a lack of knowledge about new ICT solutions, like healthcare platforms. The combination of these factors results in healthcare platforms having a hard time convincing organisations to choose their solution.

Interestingly, in contrast to HP1, HP2 and HP3, HP4′s strategy does match with a lot of characteristics of multi-sided platforms from other industries. HP4 is a new market entry with the aim to change the existing market. At this moment, the need for integrations is high, but the companies that offer integration solutions are scarce and ask for high prices. This discourages especially smaller organisations from realizing integrations. HP4 raised extensive investment capital to subsidize users and to create indirect network effects. As they make it financially feasible for all kinds of organisations and applications to connect, they are much more likely to scale the platform. Also, their costs will be substantially lower in the long run, because they focus on the reuse of the same integrations. However, representatives of HP4 also mentioned that they do have a hard time dealing with the specific characteristics of the healthcare industry. Healthcare applications are often less innovative as they are, for example, often not proficient in using APIs. In combination with the absence of quality marks, these are factors that make it hard for healthcare platforms to scale at a fast pace. Besides, realizing a business model for connecting applications in healthcare is challenging due to the distinctive logic of the healthcare sector that advocates for the protection of patient data and the existence of indirect payers, like health insurers. However, as the demand for the digital support of healthcare processes grows and the number of IT parties in healthcare is small, there is a need for platforms that keep the costs low. Platform business models, like HP4′s, can be a solution for this.

Limitations and recommendations for future research

The first limitation is the generalizability of the findings to other healthcare platforms, which is comparable to case study research in general. Although the finding revealed preliminary success factors regarding healthcare platforms, most findings are exploratory and based on the first conjectures so far. While little comparable research is executed on healthcare platforms, this is not the case for platforms from other industries. For example, in a fellow student's explorative multiple case study research, a conceptual model was developed based on the most important success and failure factors for auction platform organisations (Kolff, 2020). The results show that there is a variety of strategic decisions made by platforms based on many different situations and contexts. For healthcare platforms, this is related to the functions they focus on but also on whether they are part of a larger organisation, similar to the findings of Kolff (2020) and others (Yoffie et al., 2019). Case 1 and 2, for example, benefit from the organisations′ network and financial capabilities. These findings confirm that certain theories from platforms in general also apply for platforms in the specific context of the Dutch healthcare sector. However, for the results of this study that are specific to healthcare platforms and which are considered

as theoretical extensions, it is not possible to claim wide applicability and further research is necessary to be able to do so.

Moreover, the research method in which a maximum of two representatives was interviewed for each company resulted in more superficial insight in multiple cases instead of deep insights in only one or two cases. This approach was considered appropriate for the explorative goal of this study, but it resulted in a lower validation of the results of the interviews. Despite efforts to triangulate the data by using different sources, the method of data collection and analysis may be biased by the inclinations of interviewees and the interviewer. Although several measures were taken to increase credibility, further research is necessary to strengthen, fine-tune, compliment and validate the success factors and the corresponding model that were discovered in this study. As this study only considered a limited number of cases in the specific Dutch context, another recommendation for further research is to do more extensive, comparative studies across different platforms and initiatives in different countries.

Furthermore, the findings of this study show that the concept of platforms in Dutch healthcare is relatively new and there is often no consensus among different stakeholders on the functions they fulfil. As mentioned in the theoretical framework, healthcare platforms from this study can be roughly divided into technology platforms, enabling connections between systems and applications, and collaboration platforms, which enable collaboration between healthcare providers and patients directly. In the first instance, the technology platform category was the focus of this study. However, in the data collection phase, it was noticed that especially case 3 showed mostly signs of a collaboration platform as they connect healthcare providers in their own environment. They provide functions, similar to technology platforms, more out of necessity. Case 2, on the other hand, owns collaboration platforms, or collaboration applications as they call them, within their product offering. Their main focus is however to combine their integration solutions with these applications to facilitate service integration among organisations. In addition to the focus on technology platforms, the predetermined focus was also on multi-sided platforms. HP1 and HP4 can be considered two-sided as they have an end-user side, consisting of healthcare organisations, and a side consisting of third-party healthcare application developers. Besides, HP3 can be considered as two-sided as they connect the network of healthcare providers with patients through PHEs. On the contrary, HP2 mainly interacts with end-users and prefers to acquire applications to make them part of their product offering. In the interviews, the representatives of HP2 indicated that they closely collaborate with parties that have a joint proposition but that they can not envision the platform opening up to application developers in the near future. HP2 should therefore be considered as one-sided for which several researchers indicate that these can not be considered as platforms at all (Eisenmann et al., 2006; Tiwana, 2013). Instead, HP2 can be seen as a service to facilitate connections for healthcare organisations to all kinds of parties they want to connect to. As almost every successful platform started as one-sided, HP2 also has the possibility to add a second side and transform into a multi-sided platform in the future. It is interesting to note that the collaboration applications within HP2′s product offering are comparable to HP3 and can be seen as two-sided when they connect healthcare providers and patients. All in all, it is recommended to emphasize distinguishing the different design aspects and functions of healthcare platforms during the selection of cases in future case study research. The findings of this study show that healthcare platforms can have very diverse functions, strategies and design aspects, and can not always be considered as multi-sided platforms. Dependent on the goals of the research, researchers should take this into account as the selection of the correct cases is necessary to ensure good case study research (Eisenhardt, 1989; Seawright & Gerring, 2008).

In summary, this study leads to a further understanding of the success factors and their dynamic relations for platforms in healthcare. Healthcare platforms show great potential to support healthcare organisations to exchange information and integrate and innovate their healthcare processes. However, further research is necessary to explore the effects of platforms on the performance of healthcare delivery by measuring along multiple dimensions, such as the quality and the costs of care. Interdisciplinary and longitudinal research designs are necessary to monitor and analyse these developments. Longitudinal research may also be useful to capture the dynamics of platform evolution in healthcare.

Practical implications

In conclusion, the results of this research can support companies with platform business models in healthcare. It is presented how Dutch healthcare platforms can be successful in achieving information exchange, service integration and service innovation. This can support platform owners on key design and governance choices and help them to pay appropriate attention to environmental dynamics. Important to note is that the research is focused on the Dutch healthcare setting and that most findings are exploratory and based on first conjectures. Managers should carefully consider copying the findings as these are based on a specific context and probably not complete.

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Appendix I – Results literature review

Table 1: Results from literature review on platform and ecosystem typologies

	Typologies			
	Transaction platform	**Innovation platforms**	**Multi-sided market**	**Platform ecosystem**
Adner & Kapoor, 2010				✓
Armstrong, 2006			✓	
Cusumano, 2019	✓	✓		✓
de Reuver et al., 2018			✓	✓
de Vasconcelos Gomez, 2018				✓
Eisenmann et al., 2006			✓	
Evans, 2003			✓	
Evans & Schmalensee, 2005			✓	
Evans & Schmalensee, 2010			✓	
Evans & Gawer, 2016	✓	✓		
Gawer, 2014			✓	✓
Gawer, 2020	✓	✓		
Gawer & Cusumano, 2014			✓	✓
Jacobides et al., 2018				✓
Koskinen et al., 2019	✓	✓		
Parker et al. 2016				✓
Rochet & Tirole, 2003			✓	
Rysman, 2009			✓	
Tiwana et al., 2010				✓
Van Alstyne et al., 2016a				✓

Appendix II – Case study protocol of Eisenhardt

Table 1: Case study protocol of Eisenhardt (1989)

Step	Activity
Getting Started	Definition of research question Possibly a priori constructs Neither theory nor hypotheses
Selecting Cases	Specified population Theoretical, not random, sampling
Crafting Instruments and Protocols	Multiple data collection methods Qualitative and quantitative data combined Multiple investigators
Entering the Field	Overlap data collection and analysis, including field notes Flexible and opportunistic data collection methods
Analyzing Data	Within-case analysis Cross-case pattern search using divergent techniques
Shaping Hypotheses	Iterative tabulation of evidence for each construct Replication, not sampling, logic across cases Search evidence for "why" behind relationships
Enfolding Literature	Comparison with conflicting literature Comparison with similar literature
Reaching Closure	Theoretical saturation when possible

Appendix III – Interview protocol

Interviewnummer en datum:

Voorstellen en alvast bedanken voor tijd.

Introductie

Dit onderzoek is onderdeel van mijn masteropleiding Business Administration aan de Universiteit Twente en ik doe dit onderzoek in opdracht van M&I/Partners. In dit onderzoek wil ik gaan bepalen wat de kenmerken van zorgplatforms in de Nederlandse markt zijn. Ik zal een aantal vragen stellen over jouw ideeën, meningen en afwegingen over dit onderwerp. Dit interview zal ongeveer een uur in beslag nemen.

Voordat we beginnen, zou ik graag toestemming willen hebben om deze sessie op te nemen. Er zal vertrouwelijk worden omgegaan met de opnames.

Ik wil daarnaast nog aangeven dat de deelname aan dit onderzoek volledig vrijwillig is en dat je op elk moment, zonder reden, bij mij kan aangeven dat je niet meer wilt deelnemen aan het onderzoek. Daarnaast is het belangrijk dat je weet dat de definitieve versie van mijn thesis wordt gepubliceerd en opgeslagen binnen de UT op https://essay.utwente.nl/ en dus openbaar beschikbaar zal zijn. Ik wil daarom vragen in hoeverre je het goedkeurt dat de informatie die tijdens dit interview wordt besproken naar het bedrijf terug te herleiden zijn. Er zijn hiervoor twee opties waaruit je kan kiezen:

- De bedrijfsnaam kan onder een pseudoniem worden genoemd in het onderzoek. Specifieke informatie is hierbij terug te koppelen aan dit pseudoniem.
- De bedrijfsnaam kan worden genoemd in het onderzoek, waardoor specifieke gegevens terug te koppelen zijn aan de bedrijfsnaam.

Heb je voor we het interview beginnen nog vragen die je wilt stellen?

Thema	Sub thema	Vragen
Algemeen	Functie geïnterviewde	Zou je kort jouw functie binnen het bedrijf kunnen toelichten?
	Oorsprong	Hoe en wanneer is jullie platform ontstaan? o Zou je kort de tijdlijn van het zorgplatform kunnen bespreken? o Transitie van transactie naar innovatie platform?
Functie	Functie platform - Interoperabiliteit - Verdienmodel	Hoe zou jij de functie van jullie platform omschrijven? o Wanneer we kijken naar het vijf-lagen model van Nictiz, op welke lagen verbinden jullie dan jullie gebruikers? o Welke functionaliteiten biedt het platform om dit te bereiken? o Wat is jullie verdienmodel? (meerdere?) o Op welke manier zijn jullie behalve een transactie platform (informatie-uitwisseling), ook een innovatie platform (toelaten van externe ontwikkelaars)? (transitie?)
Connectiviteit	Markt - Kanten (sides) - Locaties	Wat voor een soort gebruikers zijn verbonden aan jullie platform? o In welke groepen kunnen deze worden ingedeeld? (zorginstellingen / ontwikkelaars) o Verschillende regio's in Nederland?
	Netwerk effecten - Direct - Indirect - Kritieke massa	In hoeverre verbetert de kwaliteit van het platform wanneer meer gebruikers aansluiten? o In hoeverre hebben jullie ervaren dat jullie een bepaalde hoeveelheid gebruikers nodig hebben om het platform te laten groeien?
Aantrekkelijkheid	Competitie - Multi-homing - Omhulling - Samenwerking	In welke opzichten ervaren jullie competitie van andere zorgplatforms? o In hoeverre ervaren jullie dat jullie gebruikers meerdere platforms tegelijk gebruiken? o In hoeverre is het mogelijk dat een ander bedrijf/platform de functionaliteiten van jullie platform overneemt? o Hoe voorkomen jullie dit? o In hoeverre werken jullie ook samen met andere platforms/partijen?
	Differentiatie - Verticaal - Horizontaal	Op welke manieren differentiëren jullie je van andere zorgplatforms? o Op welke functionaliteiten / standaarden / infrastructuren van het platform focussen jullie je? o Op welke soorten zorginstellingen en regio's focussen jullie je?
	- Prijsstrategieën - Reputatie - Vertrouwen	Op welke manieren trekken jullie gebruikers aan? o Maken jullie gebruik van bepaalde soorten prijsstrategieën? Welke en waarom? o Welke rol speelt jullie reputatie? o Hoe zorgen jullie ervoor dat gebruikers jullie vertrouwen?
Verbinding	- Open/gesloten architectuur - Open/gesloten bestuur - Controle	Hoe verbinden jullie gebruikers aan jullie platform? o Hoe open is jullie platform voor buitenstaanders? o Verschil gebruikers / ontwikkelaars? o Hoe zorgen jullie ervoor dat gebruikers mee kunnen ontwikkelen aan jullie platform? o In hoeverre kunnen gebruikers meebeslissen in het bestuur van het platform? o In hoeverre profiteren gebruikers van de groei van het platform? o Hoe behouden jullie een hoge kwaliteit binnen jullie platform?
Toekomst	Toekomstplannen	Op welke manieren zorgen jullie ervoor dat jullie voorbereid zijn op de toekomst? o Hoe gaan jullie het platform verder ontwikkelen? o Zijn er bepaalde problemen waarvan jullie verwachten dat jullie er in de toekomst mogelijk tegenaan gaan lopen? (innovatie platform)

Afronding

We zijn aan het einde gekomen van dit interview. Heb je nog toevoegingen/opmerkingen/vragen?
Mocht ik nog vragen hebben na het interview, zou ik je dan mogen mailen of bellen?
Wil je een samenvatting van de resultaten uit het onderzoek?

Bedanken voor het interview.

Appendix IV – Within-case analysis

Healthcare platform 1

HP1 is currently the market leader in the field of hospital HISs in the Netherlands, with 50 hospitals having a contract with HP1 in 2018. The company's primary vision is to continue to develop innovative software that supports and facilitates every healthcare provider to deliver the best possible care for patients. At this moment, they deliver a limited amount of HISs to other types of healthcare organisations, like GPs, independent treatment centres and rehabilitation centres, but their secondary ambition is to further expand their national and international market share to introduce their healthcare ICT to as many healthcare providers and patients as possible.

The platform of HP1 can be seen as a shell around their information system. They use the platform as a gateway towards their own HIS users and for them to make connections to other parties or networks of initiatives. The networks of initiatives are often designed in a way that connections have to be made, adjusted and maintained to the HIS. Within the network, the connections are standardized, but the connections from the HIS to the network are not. At this moment, HP1's platform offers, for example, the only entrance to the network of initiative I and their HIS customers are thus forced to use the platform to access the initiative. Besides, for connections to other HISs, HP1 only partners with other platforms and does not realize connections with HISs of other suppliers themselves.

HP1's platform is a fully managed environment in which data minimization is a design aspect. This means that copy's of health records are not stored in this environment but stay in the HIS. HP1's platform can be seen as a node or hub, connecting digital apps and healthcare organisations. The healthcare applications are seen as extensions to the HIS. These applications provide some form of a service in which they support healthcare processes. They create indirect network effects by offering applications access to their HIS customers. They also ensure that the added value for their HIS customers is enlarged by selecting all different kind of high-quality applications. Besides, applications do not have to pay any costs to connect to the platform.

HP1 also supports healthcare organisations to comply with laws and regulations. It is for example obligated for a patient to give consent before his information can be exchanged with other healthcare organisations. HP1 has responded to this by building a tool on the platform in which patients can indicate which organisations are allowed to receive information.

Functionalities

HP1's core product is its HIS. To supplement this product, they offer a healthcare platform as a service. They try to position the platform separately from their HIS product. Three main functionalities were discussed in the interviews. Firstly, based on the XDS technology, the platform creates its own XDS community and can connect to other communities. Within and between the communities, images and documents can be exchanged. Since mostly open standards are used, other platforms or integrators can also access HP1's community.

Secondly, by participating in initiative I (MedMij), HP1 complies with the trust framework for connections to PHEs. They use the set of standardized APIs to be able to connect to all PHEs that participate in the initiative. Lastly, based on FHIR APIs, the platform connects to healthcare applications that support digital healthcare provision. Examples of functions of the healthcare applications are home monitoring, shared decision making, referring and chatting using bots. They use a technical model, based on Health and Care Information Models (HCIM), to exchange data with applications. Besides, each healthcare organisation has its own in-house app store with their own assortment of trusted apps. See also figure 1 for a schematic representation of the functions and interfaces of HP1.

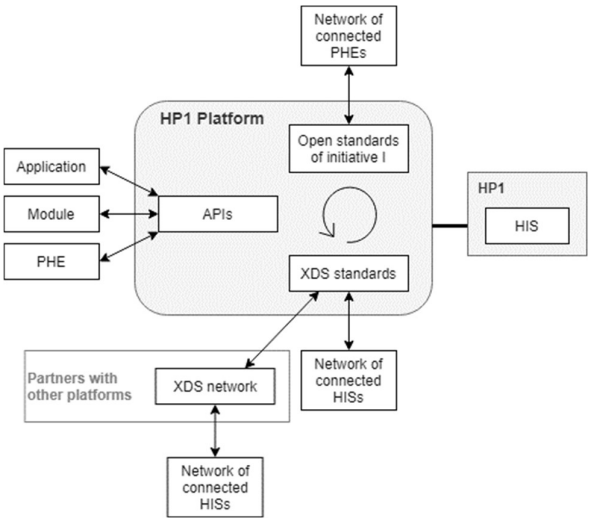

Figure 1: Schematic representation of functions and interfaces of HP1

Healthcare platform 2

HP2 started 40 years ago with an e-mail service that enabled to securely send messages between organisations and healthcare providers within the organisations. Over the years, they developed their platform as a complete solution for information exchange and collaboration between healthcare organisations. Nowadays, HP2 deploys an independent platform to which more than 24.000 healthcare organisations and more than 500 different systems and devices are connected. For years, the emphasis has been on integrating and opening up systems of healthcare organisations to exchange data about patients electronically between healthcare providers in healthcare networks. HP2′s vision is to contribute to better and more efficient care by effectively connecting healthcare organisations, healthcare providers and patients through the digital exchange of medical data. They want to become an experienced and reliable guide to secure information exchange about and with patients.

In every collaboration between organisations, the first step is to enable information exchange between the information systems of the organisations. Only when this has been arranged, additional functionalities can be made possible. HP2 specifically focuses on customer demand and use cases, which are specific situations in which the platform could potentially be used. Besides, according to HP2, the maturity of the cooperation between organisations determines which solutions for information exchange and collaborations are relevant. When the degree of organisation in the collaboration is low, a subscription to one of their communication services is often enough. When the degree of organisation in the collaboration is higher, several integration solutions may be the most suitable solution to support the collaboration. When these integrations are realized, organisations can also easily start to use applications in which they can collaborate.

HP2 also works closely with various other parties. HP2′s ecosystem of partners includes three categories. Firstly, channel partners promote one or multiple modules of the platform. HP2 has strategic partnerships with these types of parties. Examples of these partners are application owners, where HP2 facilitates the information exchange between the users of the application with their integration solutions. The second category consists of solutions partners. These partners enable additional functionalities or facilitate the service of the platform. HP2 sells their products based on a license fee. As these kinds of applications are already widely used, it is difficult to make them part of the platform. The final category consists of their technology partners. These are developers of systems or applications in healthcare who can maximise their reach by connecting to the platform. HIS suppliers and healthcare applications can fall into this category.

Functionalities

The platform of HP2 is divided into three modular components, namely: a) communication services, which include chat, message and mail services; b) technical integrations for information exchange between organisations; and c) their own collaboration applications that support healthcare processes.
The secure messaging module consists of some sub-modules, including a message, mail and chat functionality. All customers that make use of the module together form a community. Nowadays, the community consists of more than 18.000 organisations. It is possible to communicate with everyone in

a secure manner both within and outside the community. One of the representatives indicated that these modules are especially sought after by organisations that want to collaborate on a low level. For them, it is usually sufficient to take a subscription to the secure messaging module.

The data exchange module consists of several sub-modules which offer three categories of secure integration solutions. The first solutions is an integration with the Dutch NEP. The National Exchange Point is a highly secured healthcare infrastructure in which the majority of healthcare organisations in the Netherlands is connected. At this moment, the network is only used for the exchange of GP and medication overviews. HP2 offers an approved connection to the infrastructure and services to help the systems of organisations comply with the requirements of the infrastructure. The second solutions is an XDS solution for which they are one of the two major Dutch providers. For this, HP2 owns an XDS infrastructure where a lot of healthcare organisations are connected to. This brings a big advantage for new organisations that connect to the infrastructure and gain access to all connected healthcare organisations in the network. In the XDS network, healthcare organisations can exchange documents and medical images through a shared infrastructure based on joint agreements. When organisations want to join the network, HP2 helps them to comply with the requirements of the network. XDS networks make patient data available from connected HISs and index it in a registry or index module that contains information about all documents and images. The final integration solution is related to HP2′s participation in initiative I. Through the initiative, HP2 complies with the trust framework for connections to PHEs. They use the set of standardized APIs that is required by the initiative. Moreover, HP2 also use these APIs to connect to all kinds of other healthcare applications.

HP2′s final module consists of several acquired collaboration applications for treating, referring and transferring patients. Exchanging information in healthcare has always been HP2′s core business. However, HP2 is currently making a transition to combine their solutions for information exchange with their own collaboration applications. Several applications are recently added to their product offering in which healthcare providers can work together to improve and integrate healthcare processes. In the interview, the representatives indicated that the company experiences competition on all modules they offer. However, none of their competitors is able to offer a complete solution in which technical integrations are combined with applications that support many different healthcare processes.
The division of the platform into several modular components allows for autonomous innovation within modules, as well as mix-and-match innovation through innovative recombination of the modules. See also figure 2 for a schematic representation of the functions and interfaces of HP2.

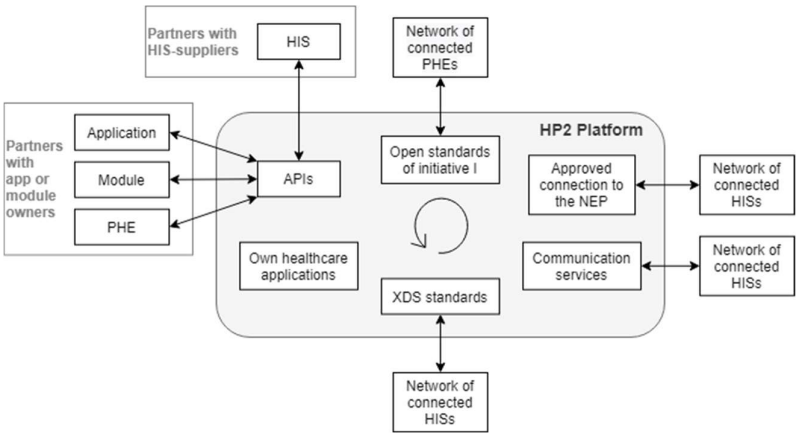

Figure 2: Schematic representation of functions and interfaces of HP2

Healthcare platform 3

The platform of HP3 enables the collaboration of healthcare providers within care pathways. To do so, HP3 connects healthcare providers based on network dynamics and designs their platform in a way that it can serve as an aid for healthcare providers to digitally support their care processes. In addition, HP3 maintains a direct connection of the platform with their own PHE and to a lesser extent to other PHEs. In this way, patients can connect to the platform and can come into contact with the network of healthcare providers that are involved in their care process.

HP3 creates network effects using the three value drivers: users, data and content. The first goal is to make it possible to exchange information between the systems of the organisations in which the healthcare providers work. The second goal is to make the available information from the different providers usable to support the care pathway, for example through dashboards. And the final goal is to provide blended care by offering functionalities in the form of applications and modules per care pathway that digitally support the care process.[2]

In order to convince healthcare organisations to join, HP3 started to organise and invest in controlled go-live projects to prove that their model adds value to healthcare processes. Because HP3 responds to the trend in Dutch healthcare in which healthcare is increasingly organised in networks instead of in silos, the platform can show that it meets the needs arising in regions or other collaboration between healthcare organisations. HP3 notices more and more that they come to the point that Dutch healthcare organisations know their worth and that their investments are paying off. The more different kinds of organisations start to connect to the platform, the stronger the network effects and the less effort and money they have to put in to persuade the organisations in the network.

Functionalities

HP3 owns a platform, which consists of a care network environment. Different than in cases 1 and 4, providers can exchange information and actively work together on the platform itself. The environment can be used by providers to coordinate and collaborate in the network around care pathways.

HP3 offers users several packages and subscriptions. They offer a basic package in which providers can exchange information with other providers from their network and with patients. They also offer a more extensive package that includes eHealth functionalities, like screening, assessment, self-monitoring, health promotion and social support, and additional subscriptions that include video calling, among other things. HP3 also cooperates with third party application and module owners. When certain applications or modules can add functionalities to the digital support of a care pathway, HP3 ensures that they are accessible for healthcare providers in the platform and for the patients through their PHE.

All providers who join the platform also have patients who will need to use a PHE to share information and to collaborate with these professionals. Apart from the business model of HP3′s platform, this does provide "a serious revenue model" for HP3′s PHE, which works best with their platform. The reason for this is that the Dutch Ministry of Health, Welfare and Sport (VWS) made a temporary financing arrangement available for the use of PHEs, The VWS pays suppliers of MedMij PHEs €7.50 for every user who has retrieved or shared data at least once via a PHE. As HP3 has their own MedMij PHE, the founder of HP3 expects that this arrangement will generate considerable profit for HP3.

By complying with the trust framework of initiative I, HP3 can use the set of standardized APIs that is prescribed by the framework. This means that the platform is able to connect with all PHEs that comply with the trust framework. HP3 especially offers access to the initiative for general practitioners and pharmacies. To do so, they build connections to the systems of these organisations themselves. In this way, healthcare providers that work in these organisations also gain access to the platform. For access of providers from organisations with other HISs, HP3 works together with other healthcare platforms, like HP2. These platforms already have communities in which the information systems of organisations are connected. See also figure 3 for a schematic representation of the functions and interfaces of HP3.

[2] The term "blended" refers to a mixture of online and offline components in a treatment process (Wentzel et al., 2016). Hereby, the online and offline components are interconnected and not standalone treatment pathways. Blended care should result in more efficiency and better quality of care.

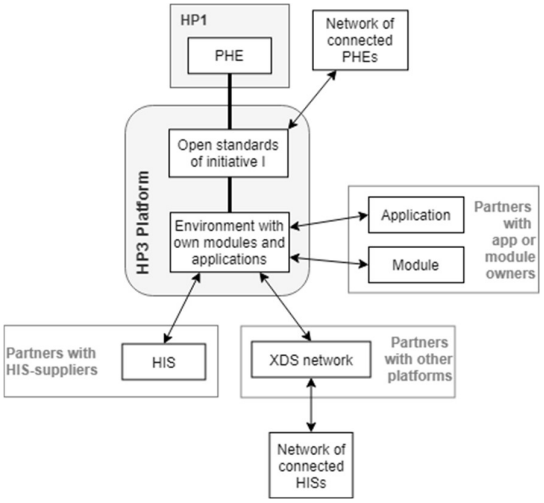

Figure 3: Schematic representation of functions and interfaces of HP3

Healthcare platform 4

The founders of HP4 have backgrounds in the development of payment platforms and were searching for a new sector for the development of a similar platform. Eventually, they ended up in healthcare where organisations are still in need of improvements in the field of information exchange and innovation.

HP4 wants to solve the biggest ICT challenges in healthcare. The first challenge is that point-to-point solutions are still being built at the moment. Together with the fact that every system in healthcare still uses its own data specifications, standards and programming languages, these factors together result in slow, inefficient and expensive integration trajectories every time there is a new need to exchange data. HP4′s solution is to introduce platform thinking in healthcare. They do this by introducing a platform that connects, discloses, translates and sends healthcare data via their uniform APIs between healthcare organisations and applications. They are convinced that their fundamentally different market approach and new, scalable technology will change healthcare by stimulating collaboration and innovation.

Functionalities

With their platform, HP4 connects applications or modules and information systems. In this way, healthcare organisations have an easily accessible choice for a large number of innovations from different suppliers. The platform is fully built according to the "privacy by design" principles and complies with Dutch and international regulations regarding the use of data in healthcare. They do not store healthcare data, but only metadata that is required for maintenance, performance, improvement, logging, monitoring and compliance. According to a representative of HP4, the company distinguishes itself from other platforms, among other things, through the qualities of its staff. Their employees have a lot of experience from working in other industries like fintech, but they also hire specialists from healthcare.

HP4 is working with modern information and communication standards and is supplier independent. They offer a SaaS platform with a uniform API based on FHIR, REST and other standardized interfaces. Their uniform API enables healthcare applications and other eHealth functionalities to offer their services to the customers of connected HISs. Once connected to the platform, healthcare organisations can select the applications of their choice. The application will then pay per transaction.

Besides, HP4 also offers a cloud-based XDS solution. This solution enables all kinds of healthcare organisations, such as hospitals, clinics, general practitioners and more, to exchange images and documents within an XDS network. Finally, HP4 uses its partners to offer access to PHEs through the networks of initiatives. As these partners comply with the trust framework of the relevant initiative, HP4 does not need to offer access to the initiative itself. Depending on the kind of information system that the organisation uses, organisations themselves can choose which partner they want to use for access to the network. See also figure 4 for a schematic representation of the functions and interfaces of HP4.

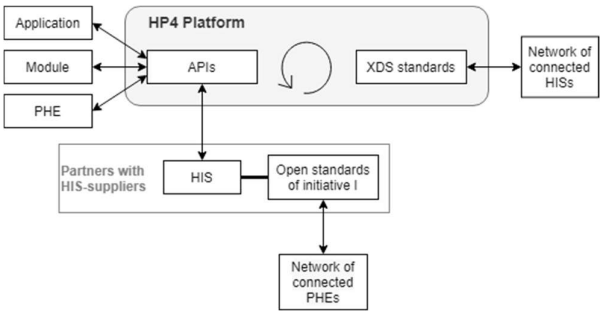

Figure 4: Schematic representation of functions and interfaces of HP4

Appendix V – Dutch health information exchange landscape

Through the years, healthcare organisations developed and managed connections with different external parties themselves. However, especially in recent years, healthcare organisations needed to maintain more and more different connections with all sorts of parties that also have to meet increasingly stricter security requirements. As a result, organisations are given more and more responsibilities to manage connections that become increasingly difficult to maintain.

To lower the responsibility, several standards were introduced with the goal to create networks for information exchange. However, to join the network, an organisation still needs to comply with its requirements. As multiple initiatives and infrastructures emerged over the years, there is still a great responsibility for healthcare organisations to comply with all their requirements, especially because they are constantly being updated. In the cases, the following were highlighted:

- When organisations want to exchange medication or GP summaries, they need to comply with the trust framework of the NEP.
- When an organisation want to exchange documents or images with other organisations, the organisation needs to comply with the requirements of XDS networks or a national initiative (II). Initiative II (Twiin) has been set up by associations of healthcare providers and patients with the goal to create a nationwide network for the exchange of images and documents. They want to achieve this by connecting existing infrastructures with each other, especially the XDS networks. In a later stadium, they also want to connect the NEP. To achieve this, a trust framework is currently being developed. However, it can take several years before a national network is created. Healthcare organisations can join initiative II free of charge since the initiative is currently being financed by Dutch health insurers.
- When an organisation wants to exchange information with patients through PHEs, the organisation needs to comply with the trust framework of national initiative I with its own standardized APIs. Initiative I (MedMij) is developed to realize standardized connections of HISs with all existing PHEs to give patients access to their health information. Initiative I consists of a separate trust framework in which FHIR APIs are appointed as the exchange standard for structured data. FHIR creates a common set of APIs that enables healthcare platforms to communicate and share data across facilities in a manner that each party can understand. This is similar to how Open Banking and PSD2 create sharing within the financial services industry.

Besides initiatives in which national infrastructures are developed for information exchange with PHEs and HISs, other national initiatives are developed with other capabilities. For example, initiatives are set up in which national tools are being developed in which patient consent can be registered and requested or in which organisations can use a national healthcare address book. The goal of the tools from these initiatives is that they act as shared services for all parties involved in information exchange. It can be valuable for platforms to start using these tools as in the current situation, patient consents need to be registered separately for every infrastructure or network and every infrastructure or network has its own address books. By using the tools from these initiatives, they can offer more efficient and cheaper solutions.

In addition, for connections that are not covered by existing open standards, organisations still need to realize and manage point-to-point solutions themselves. This is for example the case with healthcare applications or PHEs that are not part of national initiatives. The combination of complying with the requirements of several networks and maintaining the necessary additional connections to other parties makes that healthcare organisations still have a great responsibility to manage all connections to enable information exchange nowadays (see also figure 1 for a schematic representation).

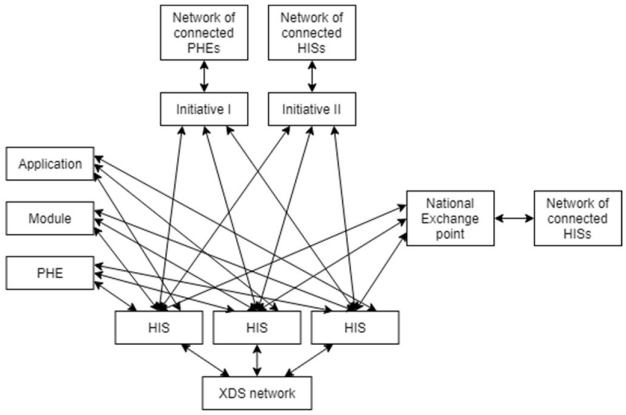

Figure 1: Complexity of the Dutch health information exchange landscape

The government is steering more and more towards the standardization of information itself and of the technical standards that are used to exchange data.[3] However, there are some limitations to standardization in Dutch healthcare. The general expectation is that the implementation of more open standards will lead to better interoperability between systems (Nienhuis, 2021a). Yet there is little reason for high expectations as the first standards date back to the 1980s and have been widely used in Dutch healthcare ICT since the 1990s. Since this widespread use, new standards based on modern technologies and paradigms always followed each other, but they have still not led to the desired interoperability.

In Dutch health ICT, standards are developed by official standardization institutes, but the standards that are used in practice are developed as specifications by the industry or by universities. The development of such specifications is embedded in the development of standards as they are submitted as candidates for standardization to official standardization institutions. However, this only happens at a very advanced stage of development. To improve this process, the involvement of the platforms in the standardization process can be of added value. The official standardization institutes then take the task of guaranteeing the quality of standards instead of developing the standards.

[3] Van Ark, T. (2020). "Kamerbrief over open standaarden en ICT-markt in de zorg." Retrieved 14-05-2021, from https://www-rijksoverheid-nl.ezproxy2.utwente.nl/documenten/kamerstukken/2020/12/15/kamerbrief-over-open-standaarden-en-ict-markt-in-de-zorg.