DECISION-MAKING IN OPEN PLATFORM NETWORKS

SENSEMAKING OF COMPLEMENTORS' INNOVATION SUCCESS IN A NEW PLATFORM

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Doctor of Philosophy

Aston University

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Summary

With the rise of open platforms, the position and involvement of complementors in the app economy are becoming incredibly prominent. However, making sense of the platform ecosystem and building a strategy to reach a competitive advantage has been a challenge for complementors since the formation of open platforms.

This research investigates complementors information processing and decision-making after joining a new platform. A conceptual framework has been developed as the result of this investigation that specifies different cognitive beliefs that complementors have in forming their strategies to overcome the limitations. The empirical phase of this thesis investigated this framework taking an interpretive approach and using the cognitive mapping as a qualitative method of analysis.

The results of this study make the following contributions. Firstly, competition is among developers' knowledge and skills rather than their products in a newly opened platform. Therefore, complementors form their strategic decision-making by recruiting strong team members.

Secondly, to develop in a platform with a focus on niche markets, complementors are highly dependent on customers from the early stages of their development to be able to finish and launch their projects. Thirdly, satisfied customers and background work experiences are more critical for future development than the project's features. Finally, personal leadership style allows developers to effectively manage the production process by regularly contacting clients and addressing their project requirements.

This thesis has made a contribution to cognitive mapping approach by introducing a new approach for data collection. Using Google Docs as an online platform allowed this study to approach participants globally. In conclusion, a longitudinal study is recommended to evaluate the changes in strengths of the beliefs developers have.

Keywords: Open Platform, Complementors, Decision-Making, Cognitive Maps, Mental Model, Schemata

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GLOSSARY

API	Application Programming Interface
APP	Application
AR	Augmented Reality
IT	Information Technology
MR	Mixed Reality
R&D	Research and Development
UK	United Kingdom
USA	United State of America
VR	Virtual Reality

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CHAPTER 1

INTRODUCTION

1.1.Research Background

The open platform is *"products, services, or technologies that are similar in some ways to the former but provide the foundation upon which outside firms (organised as a 'business ecosystem') can develop their own complementary products, technologies, or services"* (Gawer and Cusumano, 2014, p. 418). Over the past decade, many industrial firms have begun using open platform business models to maintain their competitive advantages (Yoo et al., 2012). In 2020, Microsoft, Apple, Google, Amazon, Tencent, Facebook, and Alibaba shared a six trillion dollars market value by providing complementary products/services, which indicate the flexibility of corporations in the information system sector in adopting and operating open platforms (Cusumano et al., 2020; Iansiti and Levien, 2004). Their evident success has resulted in the platform being named the most influential corporate configuration (Chesbrough, 2012; Eisenmann, Parker, and Van Alstyne, 2011). Accordingly, there has been a growing number of publications on open platform and platform ecosystem (Boudreau, 2010; Gawer, 2014; Ghazawneh and Henfridsson, 2015; Jacobides et al., 2018; Perrons, 2009; Thomas, Autio, and Gann, 2014; West, 2003).

The literature on the platform ecosystem recognises platform owner, complementors, and end-users as its three agents (Cennamo, 2019; Thomas, Autio, and Gann, 2014). As the one with the most power in running and managing the platform ecosystem, the platform owner supplies essential elements and software programs to the third-party developers (also known as complementors). Based on the platform's resources and governance rules, complementors develop innovations for end-users (Adner, 2017; Jacobides et al., 2018; Parker and Van Alstyne, 2018). Developers' ability in creating complements for software platforms has resulted in a massive growth in the app economy. Apple App Store alone has been responsible for creating over 1.5 million jobs in the US (Apple, 2017) and more than 1.6 million jobs in Europe (Mandel, 2016). With more organisations deciding to open a platform, the questions of why and how developers choose a specific platform to create their complements have become at the

centre of recent studies (Kude, Dibbern, and Heinzl, 2011; Song et al., 2018; Wang and Miller, 2020).

The emerging search into innovation and platform ecosystems has investigated this question with two different approaches: motives behind joining a platform (Benlian, Hilkert, and Hess, 2015; Chellappa and Saraf, 2010) and ability to adopt platform modular (Cenamor, Usero, and Fernández, 2013; Song et al., 2018). These perspectives orient toward gaining more profound knowledge about the complementors' understanding of the platform and its ecosystem (before joining the platform and early stages after joining the platform). It has been found that developers' skills and background knowledge help them join the right platform (Boudreau, 2010; Parker and Alstyne, 2005). Similarly, these factors have also been stated in platform adoption research, along with platform characteristics and network externalities (Song et al., 2018). As independent complementors develop most apps outside of corporate restrictions, individual-level elements can significantly explain platform adoption.

Regarding complementors behaviour and sensemaking of the platform after adopting the platform, recent empirical research has investigated the current competitive advantages of complementors in developing complementary innovations. It has been done by understanding key drivers affecting the strategic management of complementors (Altman, 2017; Benlian, Hilkert, and Hess, 2015; Cenamor, 2021; Chen, Ni, and Yu, 2019; Foerderer et al., 2018). How developers process information and make decisions has been considered a critical moderator of accountable and robust decision-making (Van Riel, Lemmink, and Ouwersloot, 2004). These factors do direct the choice of strategy and complementor's decision processes. Without a clear understanding of the platform and its ecosystem, it is challenging to form effective strategies and have a longer-term plan to stay in the chosen platform. Mainly since it plays a crucial role in understanding platform success elements (Prior, Keränen, and Koskela, 2018).

The existing literature has extensively examined the strategies employed on well-established platforms (Cenamor, 2021; Tavalaei and Cennamo, 2020) to inspect developers understanding of the platform. However, little is known about if complementors follow the same decision-makings under a new platforms' ecosystem. Despite the abundance of research on complementors, there is a limited understanding of developers making sense of a platform's ecosystem for the first time and the beliefs they form during innovation development. As

beliefs can significantly influence human activity related to information technology (Lewis, Agarwal, and Sambamurthy, 2003), lack of a deep understanding can result in discounting influences emanating developers sensemaking of the ecosystem their decisions in producing complements.

Arguably, prior research has vastly investigated platform ecosystem and complementors behaviour through taking deductive approaches and using quantitative methods of analysis (Cenamor, 2012; Chen, Ni, and Yu, 2019; Song et al., 2018; Tavalaei and Cennamo, 2020). Although this method has enabled researchers to gather information from large sample sizes, it does not capture the fundamental nature of processes developers go through to decide to produce their innovation (Orlikowski and Baroudi, 1991). Therefore, this research, by taking a qualitative approach, aims to contribute to the literature by recognising human experiences, networks of interactions, and forces by assisting with the complexity and difficulty of sensemaking (Schwandt, 1994).

1.2.Research Aim and Objectives

This thesis addresses the lack of research in complementors sensemaking of the platform ecosystem and what factors they believe create success for their innovation. Therefore, the main aim of this study is to:

- Investigate complementors' information processing and decision-making during the development of innovation.

Since a successful technological innovation is directly linked to maintaining a competitive advantage for a business, it is crucial to understand the development stage of the innovation process (Hayes and Wheelwright, 1984; Eden and Spender, 1998). Research suggests the cognition process plays a vital role in resolving any decision to adopt a technological innovation (Lowstedt, 1985; Weick, 1990). The success level of innovation can be linked to decision-makers cognition responsible for shaping business choices regarding innovation adoption (Eden and Spender, 1998). This study investigates complementors' (app developers) information processing and decision-making during open innovation development in the digital platform (when working on the Microsoft HoloLens device). This study's findings impact the

differences between decision-making in independent innovations and innovations linked to platforms.

The lack of knowledge about the influence of complementors (app developers) in the success of platforms suggests the following objectives:

- To understand what set of beliefs complementors have about the platform in the process of developing their innovations.

Literature has researched complementors behaviour from the moment they decide to join a platform until the launch of their innovation by focusing on their motivation to join a platform, how they adopt platform ecosystem, and their strategies to ensure their competitive advantages. However, the literature lacks evidence on how app developers' beliefs affect their continuing innovation development (Qiu, Gopal, and Hann, 2017). This study follows the sensemaking perspective to understand the decisions made during the development of application software innovation (Beverland, Micheli, and Farrelly, 2016; Christiansen and Varnes, 2009; Prior, Keränen, and Koskela, 2018; Samdanis and Lee, 2019; Weick, 1995). This will be about beliefs when operating within the context of MR (Dennison et al., 2018). The findings draw a nuanced and holistic picture of complementors decision-making in new platform ecosystems.

An additional objective is:

- To develop a conceptual model of complementors' decision-making to achieve successful innovations in an open platform.

The existing frameworks and models related to individual developers' effective decision-making on innovation development are based on evaluating their non-platform-based environment responses. For instance, the models suggested by Laforet (2011) and Hardie and Newell (2011) evolved around factors influencing innovation result during development and after its launch. The framework of organisational innovation and outcomes by Laforet (2010) indicate factors such as availability of customers, the complexity of technology, access to market, profit margin, work condition, rivals, unexpected changes make an impact on the outcome of the innovation (e.g., reputation, financial performance, operational effectiveness, and cost benefits). The model presented by Hardie and Newell (2011) was developed by studying the developers in the high-tech sector. This model proposes company resources, client

and ends user influence, project-based conditions, industry networks, and regulatory climates as the main potential enabling factors influencing the innovation delivery process. Their findings suggest government regulations play a crucial role in the success of innovation. Firms with more financial freedom to pay for the projects' expenses are expected to have a higher market success rate.

The main limitation of these models is that the samples were chosen from firms with no online platforms presence. Although these prior models acknowledge the importance of building successful innovations, there is a lack of focus on how complementors deal with innovation development uncertainty within a platform. Even though there are some similarities in influencing factors in platform-based and non-platform-based developers, these frameworks fail to address critical issues. These issues impact the platform governance rules, structural design, and strategies in maximising innovation performance in a platform. Therefore, this study aims to develop a comprehensive model that would consider all the essential elements and influencing factors in a developer's decision-making in a platform.

1.3.Contributions

The findings of this thesis contribute to the existing research on complementors' strategic decision-making. As prior researchers mostly focused on understanding what strategies complementors commonly use (Cenamor, 2021; Hyrynsalmi, Suominen, and Mäntymäki, 2016; Tavalaei and Cennamo, 2020; Xie et al., 2021), there is a lack of understanding in what beliefs about the platform and its ecosystem results in making certain strategic decisions. Primarily, investigations are commonly focused on well-established platforms, and there is a gap in understanding how developers would make sense of a newly opened platform's ecosystem. The literature stated that innovation's stand-alone value is critical for complementors to join a new platform (Cenamor, 2021). However, this finding alone does not ensure and encourage them to stay and continuously develop for the same platform. By studying the developer's cognitions of the new platform, this research reveals the key factors that developers believe create successful innovation. These findings will help complementors to get a greater understanding of new platforms' structure and what elements they need to consider while developing their complements. It also allows platform owners of new platforms to understand their developer's perception of the ecosystem better.

Also, current literature on sensemaking in technology literature has vastly focused on how individual make sense of new technology in organisational studies (Azad and Faraj, 2008; Karsten and Laine, 2007; Maitlis and Lawrence, 2007; Olesen, 2014; Petkova, Rindova, and Gupta, 2013). Although previous studies have examined the cognitive and social dimensions of technological sensemaking, certain other crucial factors need to be considered. This research emphasises the absence of complementors' perception of the new platform ecosystem and the lack of focus for implementation on technology science in the open platform body of research. This paper is among the first to highlight the importance of an individual's sensemaking of new technology in the open platform ecosystem research body.

1.4.Thesis Structure

This thesis is structured into eleven separate chapters. Chapter one discussed the research background, articulated the gap, and mentioned the objectives for this thesis. Chapter two focuses on the current literature around the platform ecosystem, emphasising the industry platform and its relationship with complementors. Chapter three covers the relevant strategies and cognition concepts and models linked to complementors strategic decision-making. Chapter four covers the theoretical background by looking at the sensemaking concept. It also includes schemata and human-computer interaction theories. Following this, chapters five and six focus on methodological and analytical approaches chosen based on the research objectives. Chapter seven presents findings of obtained data which are analysed through using cognitive mapping methods. Chapters eight, nine, and ten provide full detail on the developed conceptual framework in this research by looking at the antecedents and consequences of open platform innovation. Lastly, chapter eleven evaluates how this study's findings contribute to the current literature, including its managerial and methodological research implications. It also details the limitations this study faced and how researchers in the future should address these issues.

CHAPTER 2

OPEN PLATFORM STRUCTURE

This chapter aims to provide a deep understanding of the existing literature regarding complementors and their role in the platform. As complementors' decision-making highly depends on the policies and architecture of the platform, the discussion starts by shading light into the concept and configuration of platform and platform development in the high-tech industry. The second section then focuses on the role of complementors in creating complementary innovations as well as the known strategies used by them for these platforms. This structure establishes a comprehensive overview of the factors influencing the result of the innovation.

2.1.Platform in Context

The platform is defined as *"a large set of a product components that are physically connected as a stable subassembly and are common to different final model"* (Muffatto, 1999, p. 145). The term "Platform" in recent years has gained increasing attention within academic researchers, specifically in studies deliberating the development of new products and operational management (Meyer and Lehnerd, 1997; Simpson et al., 2005); industrial economics (Evans, 2003; Rochet and Tirole, 2003); and in technology strategy (Benlian et al., 2015; Eisenmann et al., 2006; Gawer and Cusumano, 2014). These authors point out the necessity of clearly understanding the platform governance and structure in literature. Their findings assist the platform owner and its complementors with minimising errors and failures in the process of developing innovation. As complementors decision-makings in a platform highly depends on the platform's ecosystem, it is essential to have a great understanding of the open platform architecture and governance rules. Having an in-depth knowledge of the contextual issues in platform structural design and the role of complementors in the platform helps this study point out the limitations and contribute to the existing literature.

2.1.1. Open Platform

Gawer and Cusumano define open platform as *"products, services, or technologies that are similar in some ways to the former but provide the foundation upon which outside firms (organised as a 'business ecosystem') can develop their own complementary products, technologies, or services"* (2014, p. 418). By creating an open platform known as an industry or external platform, large organisations become the foundation for many businesses (mainly SMEs) to produce additional complementary innovations and possibly create network effects (Gawer and Cusumano, 2014). This action is defined in the literature related to open innovation.

Chesbrough et al. (2006) define the concept of Open Innovation as *"... the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively"* (Chesbrough et al., 2006, p. 1). Open innovation as the new paradigm for innovation management has enabled organisations to outsource part of their innovation development to external agents (Chesbrough, 2006). West and Boger (2014) have developed a four-phase open innovation model highlighting the importance of obtaining, integrating, and commercialising innovations and interaction required by providing an outside-in perspective about new product development. Strong partnerships between firms lead to knowledge and skills sharing in the integration phase, potentially increasing innovation success. This ideology resonates well with how the relationship between the platform's owner and its participants is.

Immaterial or virtual networks are defined as connections are made not face to face and in physical format, but rather through agreements or the application of common rules, such as when users with same programme may share data (Shapiro et al. 1998, p. 230). The open platform consists of a two-sided network where each has separate user groups with different characteristics (Rochet and Tirole, 2003). The first group is the demand-side platform users/customers who purchase and use the product, such as electronic devices applications. The suppliers on the other side of the platform offer complementary products or services that its consumers would use on the users' side.

The advantages of network effect for goods and services are dependent on the promotion of sustainable network effects, also known as network externalities (Katz et al. 1986, p. 823),

whereas demand-side efficiencies (Shapiro et al. 1998, p. 180) or steadily rising technologies (Arthur 1989) are the root of potential advantages and a main capital value of network effect good and services. System products create only dependent or direct network advantages, such as telephones, that has no intrinsic stand-alone value and hence are ineffective when other market players would not access the comparable technology or system.

The network effect is considered as platform's fundamental element which separates itself from other business strategies (Gawer and Cusumano, 2014). It serves as a facilitator, causing or accelerating responses across platform components and connections and extending the network's reach (Evans and Schmalensee, 2007; Evans, 2009; Hagiu, 2009). It is also the reason communications inside a platform network can be considered more impactful than regular commercial exchanges. Furthermore, network effect elements provide advantages through the dissemination of implementing and enforcing, resulting in dependent benefits such as software for computer or apps for mobile phones. Platform owners' main goal is to stimulate favourable network effects (Rysman, 2004; Gawer, 2014). The development of a significant number of contributors is indeed requirement for generating such impact.

Digital platforms such as Microsoft Windows, Facebook, and Sony PlayStation include several modular elements and rules utilised in user transitions (Boudreau and Hagiu, 2009). These modular elements are managed by a structural design that denotes how all should fit together (Henderson and Clark, 1990). Users' activities should be organised based on rules (Baldwin and Clark, 2006) concerning which information should be shared, policies to control and limit behaviours, and agreements stating obligations of the users in the platform.

The platform is developed and supported by its sponsor and provider (Eisemann, Parker, and Van Alstyne, 2009). Platform providers would control the participants' actions and act like the ones whom participants should contact about the platform's tasks. By having the platform's property rights, platform sponsors have the rights of the technical modifications, deciding on the platform's design, and who should participate in either side of the market (Eisemann, Parker, and Van Alstyne, 2009). In the following discussion, this thesis refers to the platform provides and sponsors as platform owners.

Platform owners obtain value-form external complementary products and services developed by third-party developers. The research defines the third-party developers as complementors

who are "*companies that make ancillary products that expand platform's market*" (Cusumano and Gawer, 2002, p. 52). They benefit from joining the platform by getting access to its consumers, and the network effect developed from complementary innovation (Katz and Shapiro, 1994). Complementors allow platforms to have an extensive library of software, games and productivity tools. Figure 1 illustrates the relationship between the three agents in an open platform.

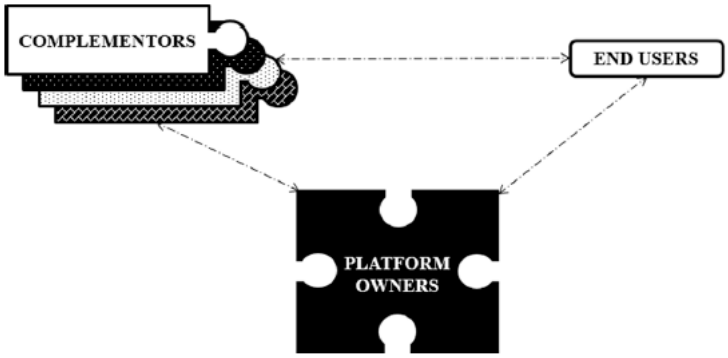

Figure 2.1: Triangular structure of agents in an open platform by Cenamor (2021)

This idea was proven by the IBM PC's success in the early 1980s and received a renewed acclaim by the launch of the apple store in 2008 (Tsui et al., 2004). This idea has been followed by many other platforms like Google, Android, Facebook, and Microsoft. To secure success, open platform owners need to have vital components which would allow them to manage the platform ecosystem effectively. Building a solid relationship with the complementors, create a competitive modular architecture, controlling intellectual properties, network externalities, and capturing market value are the main factors that would affect the owners' capability to establish and control profitable platforms (Boudreau, 2010; Ghazawneh and Henfridsson, 2013; Selander et al., 2013). A better understanding of each of these factors will help the platform owner navigate the relationships (Basole and Karla, 2012; Holzer and Ondrus, 2011).

2.1.2. Modular Architecture of Open Platforms

Simon (1962) first mentioned modularity, where he stated that the manageability of complex systems could be enhanced when hierarchical structures are used to develop and design. A product design's modularity can be described as the innovations developed with loosely coupled modular elements linked with a standardised interface (Ulrich, 1995).

Baldwin and Woodard (2009) argue that platforms embody several modules. They are low in diversity but high in reusability. On the other hand, complementary innovations built-in platforms are high in diversity and low in reusability as they follow the platform modules set primarily. Any changes to the functionality of the innovations need to be in the range allowed by the design rules (Baldwin and Clark, 2000). Due to the modular design, platforms and complements each separately cover parts of a system's architecture.

In open platforms, modular design has an opposite structure to other types (Gawer, 2009). The platform owner, who owns the modular system, does not have the responsibility of combining elements in the system as complementors should do it. Instead, they only have "*decision rights that determine who can interact with or modify which components in what ways*" (Baldwin and Woodard, 2009, p.25). As a result, platform owners find the urge to develop a resilient architecture to attract compatible third-party developers to fulfil their goals.

The platform architecture is referred to the technological competencies of a platform where modular platform elements would function and connect with the complementary innovations (Baldwin and Woodard, 2009; Tiwana, 2015). Architecture can determine the cost and how easy or difficult it would be to build innovation in a platform (Anderson et al., 2014). Therefore, a complement that is part of more than one platform would integrate differently with a distinctive quality performance (i.e., differs based on how well it runs and integrates with the target platform) dedicated to each platform. Each platform's technological performance and complexity are the main factors for this response (Anderson et al., 2014; Baldwin and Woodard, 2009). The modularity of platform architecture facilitates reducing the inter system's complexity. It occurs through dividing the central technology sub-system from each innovation sub-system. As platforms' complexity level differs based on their primary interfaces and technologies (Anderson et al., 2014), their uniqueness forms a worthwhile trade-off for multi-homing complements.

Platform's "*architectural advantage*" is based on complementarity and mobility (Jacobides et al., 2006). These factors determine a firm's ability in creating and capturing value. Complementarity implies the shared returns that come from combining multiple assets, which results in higher value creation. Mobility refers to the number of resources/products combined to create a more enhanced product. To reach architectural advantage, both of these factors need

to be high. As a result, current research on platforms (e.g., Anderson et al., 2014; Baldwin and Woodard, 2009; Jacobides et al., 2006) have researched the platform's influence on the third-party developers and its impact on value creation and value capture.

2.1.3. Platform Governance

The literature on platform governance and regulations is divided into two separate discussions. The first focuses on the necessity to govern and sustain the platform's condition and well-being (Iansiti and Levien, 2004) by controlling the quality and quantity of products being developed (Parker and Van Alstyne, 2010). This action's primary positive outcomes are the rise in platforms' value and an increase in the number of potential developers willing to adapt and develop innovation (Gawer and Cusumano, 2008). Complementors participation in a platform results in more investments in building complementary innovation (Gawer and Henderson, 2007) and increasing the chance of having "coherent" technical enhancement and expertise (Gawer and Cusumano, 2002).

The second argument about regulating the activities in platforms focuses on the profitability and improvement of the economies of scale for the owners of a platform (Parker and Van Alstyne, 2010). Platform owners play an important role in controlling as the primary private regulators (Boudreau and Hagiu, 2009). Being the "central player" has empowered platform owners to manage ecosystem members to get a higher net value for the whole platform (Katz and Shapiro, 1986). Platform owner's lack of governing leads to getting the opposite result. The critical incentive to continuously regulate and govern the platform is to obtain a share of the money generated in the platform by taxing platform transitions and sales of the complementary innovations (Boudreau and Hagiu, 2009).

- Platform Regulations

Like Sun's Internet servers, some platform owners control and take ownership of specific resources in their platforms, resulting in more interaction among members inside their platform (Boudreau, 2010; West, 2002). This action creates a unique position for the platform owners. They can build a relationship with all developers (Boudreau and Hagiu, 2009) and benefit from having access to confidential information (Boudreau, 2010). In other words, platform owners, as the public regulator, do have bargaining power (Boudreau, 2010) in controlling activities

happening in the ecosystem (Farrell and Katz, 2000). By retaining the property rights of their platforms, platform owners obtain the ownership of their assets legally. They can use these rights to prevent outsiders from joining their platform (Boudreau and Hagiu, 2009). This action also gives them power as the "licensing authority" to set a number of terms for complementors to access the platforms (Rochet and Tirole, 2003).

Platform owners' ability to determine who can or cannot join the platform provides the foundation of an inducement system for the platform ecosystem's regulation (Hart and Moore, 1990; Holmstrom, 1999). It is used to control the contribution of the platform's participants and the quality of their work. Furthermore, they have the power to regulate the complementor's interactions with the platform once they have been granted access (Boudreau and Hagiu, 2009). This regulation allows platform owners to control the types of complements that are being developed. Platform owners can also decide the platform design rules, in which they would control the quality of the innovation being developed and if it fits the platform standards (Boudreau, 2010). It is due to the fact that influencing the direction of the complements' activity can evolve the volume of value created (Jacobides et al., 2006). Any decisions and regulations made by the platform owner impact the performance of the complements. Therefore, before joining a platform, third-party developers need to know the platform rules and regulations. These can play a huge role when they start developing their complementary innovations. Researchers have started to study complementors and their behaviours to understand better how they make decisions based on the type of platforms they join in. The following section gives an in-depth overview of this topic.

2.2.Complementors Decision-Making in Open Platform

Complementors are the third-party developers who engage with a platform's ecosystem to generate and capture value (e.g., Ceccagnoli et al., 2012; Huang et al., 2013; Iansiti and Levein, 2004; Kapoor, 2018; Zhu, 2019). Research findings show the main reasons for complementors to join a platform are securing access to the platform's end-users (Chellappa and Saraf, 2010), technical documentation and support from a platform owner, and the ability to exchange ideas and communicate with other developers (Benlian, Hilkert, and Hess, 2015). In addition, the level of skills and motivation developers directly impact their ability to adapt platform information technology and create successful complements (Boudreau, 2010; Gawer and

Cusumano, 2014; Parker and Alstyne, 2005). Via these motives, complementors choose a specific platform to join in and develop their complementary innovations for it.

2.2.1. IT Platform Adoption

According to Fichman (2004), software platform adoption is an organisational choice that could be clarified through the lenses of technology planning, organisational learning, technological trend, and adaptation. Nevertheless, as independent complementors develop most software apps outside corporate restrictions, individual-level considerations can be crucial in recognising platform adoption. Evidently, individuals are counted as the main drivers of the app economy (Streitfeld, 2012). As individuals are rapidly driving the creation of software apps as well as many other forms of software systems, it is critical to investigate the way they choose a platform. Furthermore, platforms need to continually evaluate and improve complementors acceptance rate (Tiwana et al., 2010). Because the software system hardly appeals itself alone, its success and usability directly impact the complementor's decisions to adopt a platform (Katz and Shapiro, 1994).

Analysis in the IT adoption studies has repeatedly demonstrated that social experiences affect technology adoption choices (Barnett et al., 2015; Davis, 1989; Junglas et al., 2013). Moreover, platform adoption is linked to the type of market it focuses on as software creators utilise platforms to create profitable high-tech complements (Fichman, 2004). Findings indicate users want to use more valuable apps (Agarwal and Prasad, 2000). To get the end-users attention, complementors are expected to use tools with a high business opportunity and specialised technological aid (Agarwal and Prasad, 2000; Kalish, 1985). Therefore, it is required to take person-level considerations into account when studying developers' adoption.

- IT Platform Adoption

Information System studies have conducted comprehensive research on the elements that impact peoples' technology adoption decisions. These have been done through the use of a number of theories such as diffusion of innovations theory (Rogers, 1995), social cognitive theory (Compeau and Higgins, 1995), the technology acceptance model (Davis, 1989), and the unified technology acceptance and usage theory (Venkatesh et al., 2003). These theories have

allowed researchers to examine how individual and technological factors influenced the process of technology adoption. Table 2.1 provides an overview of these theories.

Theory	Explanation	Examples
The Technology Acceptance Model (TAM) Davis (1989)	• It is one of the theories commonly used when studying technology adoption. • Understanding the usefulness, ease of use, and attitude toward use are considered as the three main motives that would impact an individual's technology adoption. • The belief of the individual can be changed or influenced by some external factors	• Students' acceptance of the platform (Song and Kong, 2017) • Users' adoption and usage of Traveloka application (a travel agent company in Indonesia) (Nugroho, Bakar, and Ali, 2017) • Users' e-learning of software platforms by (Cheung and Vogel, 2013; Persico, Manca, and Pozzi, 2014)
The Unified Theory of Technology Acceptance and Usage (UTAUT) Venkatesh et al. (2003)	• This model is used to compare the similarities and differences between The Technology Acceptance Model, Theory of Reasoned Action, combined TAM and TPB, Theory of Planned Behaviour (TPB), Model of PC Utilisation, Diffusion of Innovation, Motivational Model, and Social Cognitive Theory. • According to this model, the four antecedences of accepting a technology are effort and performance expectancy, social influence and facilitating conditions. • Gender, age, experience in use, and voluntariness have been identified as the four moderation variables of this model.	This theory has not been used in open platform studies.

The Diffusion of Innovations Theory (IDT) (Rogers, 1995)	• This theory identifies five innovation adopters: early innovation adopters, innovators, laggards, the late and the early majorities. • Time, communication techniques, innovation, or social system are the four elements of defusing process. • This theory can be applied at the individual, organisational, or even global level. • According to this theory, relative advantage, compatibility, complexity, trialability, and observability are impactful elements for adopting an innovation. • This theory mainly focuses on the system, organisational, and environmental aspects. However, it lacks in portrait what the outcome would be for the innovation.	• Students' adoption and diffusion of a learning platform (Huang et al., 2020) • University student's IT adoption (Pinho, Franco, and Mendes, 2021)
The Social Cognitive Theory (TSC) Bandura (1986), Compeau and Higgins (1995)	• The key focus of this theory is on individual behaviour (usage, performance, and adoption elements), cognitions, social and physical environment (external factors). • These three factors constantly have an impact on one another. • Regarding technology adoption, this theory investigates the information technology usage based on its effectiveness, if the outcome's performance meets the expectation, and attribution, and values.	• Users' information technology usage (Agarwal and Karahanna, 2000) • Web-health users' cognitive behaviours after using the service (Anderson-Bill, Winett, and Wojcik, 2011) • Users' e-WOM behaviour (Huang, Lin, and Lin, 2009)

Table 2.1: Theories used in IT adoption studies

Although these theories investigate how an individual's adoption gets affected and changed based on IT characteristics, they cannot fully capture the essence of platform-related studies' adoption behaviour. It is due to the difference in who adopts the innovation in open platforms (Song et al., 2018). Unlike the ITs that the end-users adopt for their features, open platforms are chosen by complementors to develop/produce apps for the end-user. Consequently, in the end, it is the end-user who adapts technologies. Complementors, on the other hand, adopt a platform's ecosystem based on its usefulness and the type of end-users it has.

The findings of Fichman (2004) illustrate that clarity of the platform's possible advantages and risks can impact complementors adoption's decisions. However, his study associated platform adoption with organisational actions since software creation has traditionally occurred inside enterprises to improve organisational capacities and market value. It is because IT platform adoption is a business choice that can be clarified through the lenses of digital management, corporate learning, technology trend, and adjustment. But, because complementors develop most mobile apps, individual-level considerations play an essential role in recognising platform adoption.

However, scholars have paid limited interest to individual adopters. Levesque (2004), for instance, addresses many shortcomings in open-source software growth that are thought to have hampered consumer acceptance. However, no experimental support is given for such findings. Others also investigated managers' roles in the open platform adoption process (Goode, 2005). Although Goode investigates individual decision-making, the study objective is primarily based on enterprise adoption. As a result, managerial acceptance practises being used as proxy indicators for corporate adoption. Therefore, while complementor's IT platform adoption has undergone some attention (Sohn and Mok, 2008), there has been a greater need to examine factors impacting their adoption behaviour. Song et al. (2018) has investigated and developed a theoretical model of complementor's platform adoption by studying which factors play a significant role in adopting adoption. Their findings show these factors are platform features, personal elements, social engagement, and the system's environmental impacts.

Studying which platform features has the highest impact on complementors' platform adoption rate, factors such as relative advantage, platform innovativeness, technical compatibility, and platform openness play the most influential roles (Song et al., 2018). Relative advantage is a

critical antecedent in technology adoption studies (Choudhary and Karahanna, 2008; Thong, 1999) and is fairly comparable to TAM's concept of perceived usefulness (Moore and Benbasat, 1991; Venkatesh et al., 2003). The findings of Song et al. (2018) showed that relative advantage could be the most impactful element in complementor's platform adoption in investigating platform features. However, it depends on how innovative the platform is, like the features of an innovation influence significantly on the strategic direction of the complementor (Gatignon and Xuereb, 1997).

Previous research has also discovered that compatibility is linked to people's adoption behaviour. Innovation has a higher chance of being implemented as it is considered compatible with the currently available systems, practices, and principles of the future adopters (Karahanna et al., 2006; Moore and Benbasat, 1991; Premkumar et al., 1994; Rogers, 1995). By allowing individuals or organisations to combine new technology with current technology or processes seamlessly, organisations are able to benefit from technological compatibility (Bradford and Florin, 2003; Tornatzky and Klein, 1982). Song et al. (2018) found that complementors have a higher platform adoption rate when platforms' technologies match their skills.

The scholars have also mentioned the flexibility of technologies to allow developers to easily share insights and information throughout corporate and regional borders (Teo et al., 1997-98). Technological openness empowers and encourages complementor technology acceptance. Prior studies suggest that openness allows organisations to share innovative ideas, test them more readily, and implement technologies quickly (England et al., 2000; Rogers, 1995). There are some arguments that openness has both the technological advantage of gaining access to knowledge and the cognitive benefit of maintaining trust. It raises the likelihood of fostering innovation features (Lai and Guynes, 1997; Saleh and Wang, 1993). According to Song et al. (2018), platform openness increases complementors' chances to evaluate and implement a digital platform; it allows them to test the platform's integration with other available systems.

In studying the system's environmental impact, marketability plays a critical role in complementors' platform adoption (Song et al., 2018). The marketability of innovations allows companies to determine which inventions will be suitable to launch (Cho and Lee, 2013; Sohn et al., 2007). Song et al. (2018) suggest marketability has been affected by two elements in open platforms: market potential and available tools for complementors. Complementors are

willing to adopt the technology and features based on the platform's size, expectancy to grow in the future, and availability of supporting kits in a new platform for them.

To improve social engagement, social influence has been identified as an essential element impacting the acceptance rate of technology and innovation (Lu et al., 2005), and it is directly related to platform adoption (Song et al., 2018). According to Lu et al. (2005), when complementors are unsure of their capability in adopting a platform's features and technologies, they pursue advice from their group of networks involving other developers with knowledge and skills. Factors influencing individuals' social engagement, social norm, image, and behavioural intentions (i.e., beliefs and perceptions before and after adoption) play vital roles. Based on what personal characteristics of complementors are, their social engagement level also varies (Song et al., 2018).

Song et al. (2018) identified personal benefits, related knowledge, and personal innovativeness as crucial characteristics that impact the ability of complementors in adopting platform features. Personal benefits (Kim et al., 2007; Lee, 2009) have also been mentioned as key reasons influencing individuals' technology acceptance in studies investigating extrinsic motives (Deci, 1971; Deci and Ryan, 1985). Extrinsic motives enable a person to engage in an activity to attain certain rewards. Previous research suggests that extrinsic incentives are essential in deciding a person's behavioural purpose to accept an innovation (Kim et al., 2007). Complementors are more motivated to follow particular solutions where the model offers a higher value than current or competitive platforms.

Related knowledge about the features and technologies of a new platform also effective in complementor's adoption rate. Having a greater understanding of technologies improves the understanding of future advantages and enhances the complementor's confidence (Lu et al., 2005). Although the awareness or familiarity of complementors with technologies is linked to their responsiveness to improvement, their IT and IT perception will eliminate a lousy attitude towards emerging technology or inventions (Jeong et al., 2009). More experience that familiarises complementors with existing technology allows them to assess the value of implementing emerging technologies (Bassellier et al., 2001). Complementors with a higher level of knowledge on the effects of new technologies have a higher chance of adopting them (Thong, 1999).

Lastly, complementors with personal innovativeness are most likely to embrace inventions or technology even though the advantages are unclear (Lu et al., 2005). Personal innovativeness, in particular, is an effective and efficient characteristic that influences mental responses, including perceived pleasure (Hwang and Kim, 2007). However, perceived pleasure is less noticeable as it is proven they are motivated by functional instead of hedonistic considerations. Complementors are mostly profit-driven entrepreneurs; so, the decision is more commercially driven than only following their interests (Song et al., 2018).

These findings view factors that impact complementors' platform adoption after deciding to join in. To investigate this further, researchers also investigated complementors' actions after adoption of the platforms. The following section focuses on the findings with the focus on the most used theories in studying these.

- Theories used to study complementors behaviour in open platforms

To complementors, joining a new platform and experiencing new changes challenges managing operational structures and information processing (Liker et al., 1996). The highest level of platform ambiguity exists in "breakthrough" developments where the company would have no previous expertise or contemporary images around which to develop. The rise in product complexity is often correlated with environmental change (Carter and Baker, 1992). Due to the complexity and uniqueness of the structure of open platforms, there has been a variety of approaches taken by complementors to adopt and satisfy the expectations of both platform owners and consumers. This has raised the interest of researchers in investigating complementors behaviour in an open platform. Table 2.2 illustrate what theories have been used by researchers while studying complementors.

Authors	**Research question**	**Theory**
Brunswicker and Schecter (2019, p. 2)	*'How does the tension between coherence and flexibility affect a developer's digital innovation trajectory on open evolving platforms?'*	Problem-solving
Miric, Boudreau, and Jeppesen (2019, p. 1)	*'What appropriability strategies large and small app developers adopt to capture value on digital platforms?'*	Appropriability strategy
Saadatmand, Lindgren, and	*'How does the interplay between technological architecture and governance mechanisms generate*	Theory of imbrication

Schultze (2019, p. 2)	*platform organisations that produce different levels of complementor engagement?'*	
Benlian, Hilkert, and Hess (2015, p.209)	*'How can platform providers encourage desirable behaviours by complementors (i.e., application developers) in the absence of formal roles and hierarchical control structures?'*	Self-determination theory
Boudreau and Jeppesen (2015, p.1761)	*'Does reliance on network effects and strategies to attract large numbers of complementors remain advisable in such contexts?'*	Network effect
Kude, Dibbern, and Heinzl (2012, p. 251)	*'Why do complementor organizations within the enterprise software industry participate in hub-and-spoke networks?'*	Network effect

Table 2.2: Theories used to study complementors behaviour in open platforms

Brunswicker and Schecter (2019) focused on the tension that can rise between complementors due to the interaction and involvement on a project. Problem-solving theory allowed this research to critically investigate the complementors ability in understanding the problems, their perceptions, readiness to resolve the issue, and possible strategies that could be used to solve the problem (Dostál, 2015). Their findings specify coherence and flexibility as the key factors that can successfully impact the complementors problem-solving abilities. According to Brunswicker and Schecter (2019), their coherence in the past results in a higher level of change in approach and flexibility in the future, which directs complementors toward a steadier result.

Miric, Boudreau, and Jeppesen (2019) research concentrated on strategies complementors use/adopt in order to obtain values in a platform. Appropriability strategy allowed this research to measure the level of firms' protectiveness and profits from their complementary application in a platform. Their findings illustrate two types of strategies constantly used by complementors: formal and informal protections. Formal protections refer to copy and trademarks. It is not used as often as informal protections, including versioning and lead time. Larger organisations may use a mixture of formal and informal protection as part of their strategies to boost their success level in the platform. It is opposed to smaller businesses run by complementors that mostly focus and apply informal protections.

Saadatmand, Lindgren, and Schultze (2019) paper focused on the impact of technological architecture and governance mechanism on the level of complementors engagement level in a platform while using the theory of imbrication. According to an imbrication approach, the social and material drivers of work organizations intersect and support each others to produce

adjustments in everyone's relationships and the material attributes of artefacts. This study focuses on both horizontal and vertical platforms. Vertical platform refers to platforms that tackle a specific range of difficulties in a particular manner. These platforms often handle a specific industry or challenges that are generally comparable throughout sectors. Horizontal platform does not target a specific topic but instead supply the resources required to tackle challenges over several sectors. Rather than having pre-built, the offering or service is specially designed to meet the demands of the clients. Findings of this study illustrates a higher level of interaction and networking among complementors in horizontal platforms.

Benlian, Hilkert, and Hess (2015) concentrated on the ways platform owners can encourage suitable behaviours by complementors in a platform using self-determination theory. This theory provides a comprehensive framework for investigating individual motivation and personality. Findings of this study states that complementors' contentment, perceived value, and continued participation intentions appear to be solid and stable throughout IT platforms. The variation in level of strength gets linked back to the governance rules and architecture of that open platform.

Papers written by Boudreau and Jeppesen (2015), and Kude, Dibbern, and Heinzl (2012) used network effect theory while studying complementors behaviour. According to Katz and Shapiro network effects is defined as *"the value of (a) membership to one user (which) is positively affected when another user joins and enlarges the network"* (Katz et al. 1994, p. 94). When the number of adopters grow, the resultant value also increases, because the complementors now have more developing connection partners and one's decision making can influence the behaviour and actions of others.

The research done by Boudreau and Jeppesen (2015) showed complementor's app design reacts to platform expansion regardless of the absence of sales promotion. Acquiring complementors does have a net zero impact on continuing development and unable to generate network effects. High association involving platforms utilisation, the number of complementors, creation rates, and other factors are all compatible to network effects. However, they can also be false associations with platform features. While complementors are still desirable, having a high quantity of them no longer makes a conscience dynamic in which development generates expansion. Similarly, unpaid complementors would result in lower

barriers of entry for platforms compared to compensated complementors (cf., Bresnahan, 2002).

Kude, Dibbern, and Heinzl (2012) focused on the complementors decision to participate in hub-and-spoke networks. Hub refers to a virtual network which serves as a single point of management for outer relationship and hosting resources that are utilised by different applications. Virtual networks which contain applications and link to the main hub via virtual network bridging are referred to as spokes. Through use of network effect theory this research has found, the hub's credibility and capacity to supply integrated solutions are both crucial factors in networking. On the other hand, the level to which the hub's creativeness and financial investment urge spokes to cooperate was significant. These disparities are caused by high level of diversity in complements. This supports the argument that the establishment of hub-and-spoke relationships is explained by a frequently overlooked significant relationship seen between input- and output-oriented viewpoints.

2.2.2. Factors Impacting Complementors Engagement in Open Platforms

Complementors' engagement with platform activities can lead to further contributions in developing products or services and obligating its rules and processes (Jacobides, Cennamo, and Gawer, 2018; Boudreau and Jeppesen, 2012; Eaton et al., 2015). Factors such as their software review process or its ability to be ported to other platforms, financial benefits of developing complementary innovation, and competition in a platform have been found as critical reasons for contributing to a platform (Ghazawneh and Henfridsson, 2013; Bergvall-Kåreborn et al., 2014). Continues engagement with the end-users and developing a network effect with other developers play critical roles for complementors in the platform. However, the platform's performance depends on how effectively its developers can deal with the ecosystem (Nidumolu, 1995; Barki, Rivard, and Talbot, 2001).

Previous platform studies have shown a favourable association between the number and diversity of complementors. Complementors with a higher level of contribution increase the chance to take a stable adaptive route towards domination (Eisenmann et al., 2011; Jacobides, Cennamo, and Gawer, 2018). Many platform articles have focused on governance to control complementor's interaction inside the platform (e.g., Huber et al., 2017). Several findings have started to consider "*that the choices about who ought to make what decisions are*

intertwined with the architecture of the governed information technology artefact" (Tiwana, 2015, p. 40). Figure 2, shown below, is from research done by Saadatmand et al. (2019, p.3). It summarises the findings on platforms' design and governance structures with consequences for the participating complementors.

Papers that explore platforms as configurations of architecture and governance.

	Characteristics			
Articles	Platform	Architecture	Governance	Contribution
Cennamo et al. (2018)	Videogame consoles requiring proprietary language coding by complement developers	Modular, layered architectures comprised of technology core and interfaces create different levels of integration complexity	Developing products for multiple platforms (i.e., multihoming) affects competition between platform owners and complementors	Strategic and technical parameters must be considered to explicate the dynamics of platform evolution
Wareham et al. (2014)	Technology ecosystems include core components made by a platform owner and complements developed by autonomous firms in the periphery	Layered architecture with loosely or tightly coupled interfaces (i.e., architectural control points) between core components and complements	Cultivating an ecosystem of complementors for generativity by reconciling the paradox of change (i.e., stability versus evolvability)	Governance mechanisms for managing tensions pertinent to technology ecosystems
Tiwana (2015b)	Software platforms are created by a single platform owner and serve as an extensible technological foundation on top of which outside firms can build applications	Modularized architecture that minimizes interdependence between subsystems allowing them to change independently yet to interoperate	Viewing decision rights and architecture as a system of interlocked choices that jointly influence coordination cost	Implications of the interplay between decision rights and architectural configurations (i.e., component decoupling and interface standardization)
Kapoor and Agarwal (2017)	Business ecosystems orchestrated by a single platform owner setting the rules for complementors	Technical architecture comprised of components (or subsystems) that interact with complementors' products	Managing structural (i.e., technological interdependence) and evolutionary (i.e., technology transitions) features of an ecosystem shapes value appropriation among complementors	Varying levels of ecosystem complexity lead to trade-offs that platform owners and complementors must reconcile over time
Karhu et al. (2018)	Open digital platforms hosted by a single firm inviting third-parties to contribute improvements and add complements	Architecture modules with standardized interfaces that can be combined to generate alternative products and platform features	Designing boundary resources so that they maximize generativity and minimize exploitation (i.e., forking)	Platform ecosystems are hostile competitive environments that demand proactive defense strategizing
Kazan et al. (2018)	Digital platforms include an owner and complementors cocreating firm-specific components that render valued derivates	Technical architecture made up of modular components that third-parties exploit for value creation	Configuring architectures is a means for platform-driven strategic groups to bolster their competitiveness	Integrative and integratable architectures offer direct, indirect, or open access to distribute value among actors
Ondrus et al. (2015)	Multi-sided platforms governed by an organization that creates value by enabling interactions between two (or more) distinct types of customers	Set of stable components that supports variety and evolvability by constraining linkages among the other components	Striking the right level of platform openness is imperative to maximize market potential and likelihood of subsequent success	Strategic decision model that helps to verify whether a platform satisfies necessary openness conditions of ignition
Ozalp et al. (2018)	Videogame consoles owned by a product maker orchestrating a population of game developers	Modularized technical architecture that demands specialized programming language through its interfaces	Balancing the trade-off between platform capabilities and complementor challenges through architectural design and routine invention	Interdependence between technological transitions and their impact on complementors disrupts value creation in ecosystems
Pagani (2013)	Multi-sided platforms managed by a single actor who control functional components to organize edge and core competencies of ecosystem players	Component-based architecture that affords value creation and capture in digital ecosystems	Configuring control points enables implementation of functional components required to deliver a service offering	Strategy insights about the dynamic process by which two-sided markets and supportive platform solutions emerge
Parker et al. (2017)	Digital platforms are governed by an individual firm interacting with an ecosystem of external developers	Layered architecture of digital technology that includes device, network, service, and content layers	Influencing developer innovation through platform resources and licensing agreements	Platform firms maximize growth by optimizing their own intellectual property regimes
Song et al. (2018)	Two-sided platform markets characterized by a software firm orchestrating both end-users and third-party developers that supply complementary apps	Technological architecture that includes extensible codebases of software systems that provide core functionalities	Shaping the mutual influences between the app-side and the user-side of software platforms	Governance implications of the temporal dynamics that underlie the interdependence between the two sides of a platform
Spagnoletti et al. (2015)	Digital platforms provide a socio-technical foundation upon which diverse actors can develop complementary products, technologies, or services	Layered modular architecture comprised of core and peripheral components and interfaces linking them to complements	Devising coordination mechanisms that build on mutual, reciprocal adjustments as well as hierarchical and formal control	Propositions that help to design and implement core elements, interfaces, and complements of digital platforms
Jacobides et al. (2018)	Interorganizational systems stipulating agreed and predefined ways of interaction	Technological modularity mediated by rules of engagement, standards, and codified interfaces	Tying ecosystem members together in a web of interdependent yet autonomous activities (i.e., coordination without hierarchy)	Role of modularity and impact of different types of complementarities
Dattée et al. (2018)	Industry platforms building on shared standards and interfaces	Layered digital infrastructures that include lower-level layers (e.g., physical components) and user-facing layers (e.g., applications)	Balancing value creation and capture characterizes the ecosystem game between initiators and other actors	Generativity of an enabling technology is leveraged by dynamic control points that distribute the generation of alternatives to suitable actors
Jha et al. (2016)	Technology-enabled ecosystems assembling components from various actors	Modularized infrastructure based on loosely coupled integration	Aligning components of an ecosystem so that they influence each other and evolve into integrative innovation	Stakeholders create value for themselves when they increase the collective pool of human, economic, and material resources

Figure 2.2: Articles that studied platforms' architecture and governance with their impact on developers taken from Saadatmand et al. (2019)

Most of these articles focused on software platforms (e.g., Kapoor and Agarwal, 2017; Karhu et al., 2018; Ozalp et al., 2018). The findings illustrate that the platform owner creates the system and makes strategic decisions based on the platform's architecture and governance rules. The above studies showed the following platforms mostly focus on the link between technological and social aspects of developers' engagement (Cennamoet al., 2018). For instance, Tiwana (2015) argues that elements de-coupling and software standardisation can minimise synchronisation expenses. So, if the architecture is incompatible with complementors' decision rights, there is a high chance that they would leave the platform. Therefore, complementors need to obtain and follow specific strategies that fit the platform expectation and capture value.

2.2.3. Strategies Used in Open Platforms

Complementors create and follow specific strategies while being on a platform to maintain their competitive advantages and profit from developed complements. Complementors take strategic moves that impact adjacent commodity markets and the entire ecosystem (Hilbolling et al., 2019; Inoue, 2019). A number of publications helped illustrate a variety of perspectives on used strategies by complementor (Altman, 2017; Benlian, Hilkert, and Hess, 2015; Foerderer et al., 2018).

Recently, research has investigated various roots into complementor strategic gain by assessing the conventional factors of platform acceptance, namely efficiency and production capacity (Ozalp, Cennamo, and Gawer, 2018; Rietveld and Eggers, 2018). However, the insights remain incomplete since they are derived from observational analyses in various technical environments such as the social media platforms (Saarikko, Westergren, and Blomquist, 2017), applications (Karjaluoto et al., 2019; Zhou and Song, 2018), and video games (Choi et al., 2018). Moreover, these studies have been done on well-established platforms with a large number of active developers. Table 2 summarises the most commonly used strategies by the developers.

Articles	Strategies	Description
Ozalp et al. (2018) Rietveld and Eggers (2018)	Stand-alone value	1. This strategy is highly effective for a newly opened platform with few numbers of complementors.

Adner, Chen, and Zhu (2020)		2. Early adopter users expect a highly innovative product with good quality.
Rietveld and Eggers (2018) Yi et al. (2019)	Network Value	1. This strategy is applied in slightly matured platforms. 2. Compared to newly established platforms, it contains a larger group of active complementors. 3. End-users are less technically demanding.
Shipilov and Gawer (2019)	Bi-lateral dependencies	1. This strategy is applied when some complementors team up with the platform owner to develop
Landsman and Stremersch (2011) Wang and Miller (2019) Claussen, Kretschmer, and Mayrhofer (2013) Kapoor and Agarwal (2017)	Multi-homing synergies	4. This strategy is applied when a platform has reached its peak of maturity. 5. Complementors try to maintain their competitive advantage in the market by producing their complements for more than one platform. 6. A multi-homing strategy can result in having lower quality innovations.
Shaikh and Levina (2019) Shipilov and Gawer (2019) van de Kaa, Papachristos, and de Bruijn (2019)	Co-operative networks	1. It refers to the complementors of a platform build a strong relationship in a platform. 2. It helps with building a relationship and gaining knowledge and experience from other complementors
Barlow, Verhaal, and Angus (2019), Tiwana (2013)	Differentiated offering	1. It refers to expanding the range of innovations being developed in a platform. 2. This strategy improves complementors' competitive response to their rivals in a platform.

Table 2.3: Used strategies by complementors in open platforms

The stand-alone value (known as quality) applies to services utilised without the presence of other end-users. The first personal computers, which had the ability to sort and analyse individual information more effectively than paper-based alternatives, is a typical illustration of stand-alone value (Cusumano et al., 2019). In the context of open platforms, complementors can enjoy the lack of competition and access most end-users through the stand-alone value of their innovation. Findings show that complementors can distinguish their value scheme at this stage and create a solid competitive positioning by focusing on innovation's quality (Claussen, Essling, and Kretschmer, 2015).

The network value is taken from connections with several developers who have created a user base (McIntyre and Subramaniam, 2009). Landline telephones that enable users to contact each other and communicate are known examples of network value (Afuah, 2013). Findings illustrate the size of the platform has a direct impact on the network value strategy so that complementors would find it difficult to take advantage of the network effect when there are a large number of complementors in the platform. Therefore, the distribution and degradation of complementary products are accelerated by network effects, resulting in high rises and sharp falls (Yi et al., 2019). As the platform starts to get mature, more end users would start to use the platform services/products as they are less sensitive to the technology, and their word-of-mouth can encourage more potential users to join in. This action leads to an increase in the popularity of complements and complementors (Rietveld and Eggers, 2018). Consequently, this strategy allows complementors to gradually increase the network value of their products by creating technologies that include many users and providing online and offline networking channels.

Platform owners and a number of complementors may create unique bi-lateral dependencies embodied inter-organisational networks. Hence, it is added to the top of the ecosystem's established governance rules (Shipilov and Gawer, 2019). Complementors, in particular, should show efforts to create shared confidence, which encourages better knowledge sharing and enables them to defend one another in competitor actions. As a result, complementors' encouragement for a new platform at its actual launch is viewed as a symbol of loyalty to the partnership with platform owners (Song et al., 2018; Srinivasan and Venkatraman, 2018). Indeed, platform owners and developers' shared confidence encourages development in emerging technology and distinct, complementary goods (Kapoor and Lee, 2013). Thus,

despite the immense rivalry in established ecosystems, crucial insights on the complements environment as well as special assistance from network owners will help complementors maintain their strategic strength.

Multi-homing is a strategy applied by many complementors and refers to offering innovations in multiple platforms. Although it is considered challenging for some developers, findings indicate this strategy plays a vital role in creating competitive advantage and reach success (e.g., Lee and Raghu, 2014; Shapiro and Varian, 1998; Song et al., 2018). Complementors are rewarded for interacting with end-users on various platforms (Hyrynsalmi, Suominen, and Mantymaki, 2016). Complementors create development models to capitalise on the network effects of a broader installed base by applying their existing offerings to emerging application environments (Landsman and Stremersch, 2011). Furthermore, a more comprehensive range covering multiple systems may be necessary for complementors seeking to escape the issues associated with deep involvement in a single platform (Srinivasan and Venkatraman, 2018). Therefore, numerous complementors retain partnerships with multiple platform owners to preserve negotiating power. Nevertheless, multi-homing can cause complementors to deliver relatively low-quality innovations (Cennamo et al., 2018). Multi-homing, in particular, entails adopting innovations to multiple platform ecosystems, which necessitates unique technical, regulatory, and organisational technologies (Claussen, Kretschmer, and Mayrhofer, 2013; Kapoor and Agarwal, 2017). Such modifications are significant as the current platforms vary dramatically in technical complexity or maturity (Claussen et al., 2015).

The co-operative network is another common strategy used by complementors in an open platform. According to previous studies, developer's strategic movements are inextricably linked to the actions of other members (Srinivasan and Venkatraman, 2018). Complementors join collaborative groups due to the relationships between peers and the advantages of gaining knowledge and experience from other people. Co-operative networks enable the exchange of a broad set of inputs from a broad number of creators (Kohler, 2018). On the other hand, having many people will stymie decision-making and lower the speed of projects that demand clear guidance and vital resources to target consumers (Kohler and Chesbrough, 2019; Rukanova et al., 2019). In this regard, establishing a complement network is beneficial. Therefore, it is a dynamic challenge for the complementors to develop a network of partners (Shaikh and Levina, 2019). Choosing members requires focusing on generating value and requirements for the

ecosystem instead of the conventional standards for coalition members, emphasising the capturing of value and member characteristics. Developers capable of building a co-operative network with crucial complementary components will share particular tools and threats and improve decision-making where speed is needed (Shipilov and Gawer, 2019; van de Kaa, Papachristos, and de Bruijn, 2019).

The differentiated offering is a strategy used by developers when they are willing to develop more than one complement for a platform. Identifying a distinct market niche from its rivals is an essential task for complementary companies. Complementors can expand their range of innovations that they developed in a platform (Barlow, Verhaal, and Angus, 2019). The prospect of resource reusing allows complementors to concentrate on exploiting their specific products (Tiwana, 2014). While inspired to offer innovative complements to end-users, a significant proportion of complements depend on the shared services of platform owners and react with moderately different forms of their actual innovation to their competitors (Xue et al., 2019). Platform APIs, for example, will result in copying complementary devices.

The potential and uncertainty of the demand will inspire developers to achieve more innovative targets. Indeed, supplements with advanced inventions probably dominate the market. Developers who fail to produce more innovative products will most likely leave the platform (Zhao et al., 2019). The limited technical expertise and similar requirement in the new platform might foster the recognition of a specific proposal (Rietveld and Eggers, 2018). Well established platforms give developers accessibility to a large number of consumers via popular innovations and also a large number of smaller units of customers through niche complements (Miric, Boudreau, and Jeppesen., 2019). The rivalry is intensive at this time since a tremendous number of rivals represent a variety of diverse complements (Boudreau, 2012), and it becomes uneasy to find uncovered, enticing niches. Developers with a unique product in the industry should utilise their expertise to find unappealing small markets. It is where specific competitors are joining to seek fewer popular options (Ozalp and Kretschmer, 2018).

These findings highlighted the key strategies used by developers in open platform ecosystems. To build such strategies, complementors rely on information that promotes social and ecosystem stability (Boudreau, 2012). However, some key factors impact the information processing and decision-making of complementors and have been ignored in the above studies

(Miric, Boudreau, and Jeppesen., 2019). For instance, the firms' size of developers joining an open platform plays a key role. However, analysis is often less focused on small-sized firms, the findings of Miric, Boudreau, and Jeppesen. (2019) indicate that these third-party developers account for a large portion of the total application market. Furthermore, while almost all complementors have used early entry into a platform and fast innovation adoption/development, smaller sized firms find intellectual property rights (IPR) protections such as trademarks, patents, and copyrights essential to have as part of their strategic building. It is because protecting innovations is counted as an essential factor in fostering innovation by complementors.

Summary

In summary, internal and external environment of a platform shapes the complementors decision-making. Studying why complementors would choose a platform and what decisions they make has been central to many researchers' attention. This chapter focused on the importance of complementors role on the success of open platforms. To have an in-depth insight of the subject, discussion was divided into two sections: open platform ecosystem and complementors behaviour.

Findings indicate that open platform architecture may differ based on how open the platform is to third party developers. Therefore, this openness determines the cost and how easy or difficult it would be to build innovation in a platform (Anderson et al., 2014). Platform owners, as the public regulator, do have bargaining power (Boudreau, 2010) in controlling activities happening in the ecosystem (Farrell and Katz, 2000). Result of the prior study done by Rochet and Tirole (2003) shows policies around the "licensing authority" such as the IP ownership of the complements to set a number of terms for complementors to access the platforms plays a key role in their decision to join a platform. These can play a huge role when they start developing their innovations.

The second section focused on investigating complementors behaviour and outcome of their actions after joining a platform. The figure 2.2 illustrates the timeline of the research done on complementors in a platform.

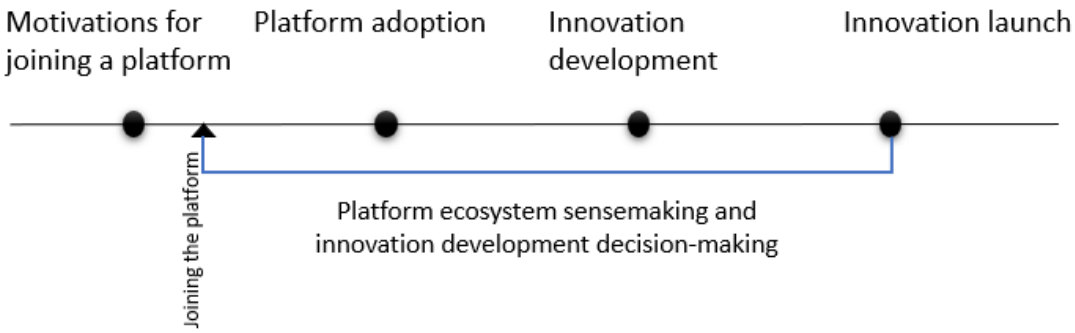

Figure 2.2: timeline of the known research on complementors of an open platform

Research findings show the main motives for complementors to join a platform has been securing access to the platform's end-users (Chellappa and Saraf, 2010), technical documentation and support from a platform owner, and the ability to exchange ideas and communicate with other developers (Benlian, Hilkert, and Hess, 2015). If these motives are met, complementors make the decision to join a platform. As it was mentioned above, platform architecture and governance rules are also factors which determines which platform they may join.

Due to the complexity and newness of platforms, complementors do need to adopt to the changes and expectations associated with the ecosystem. Song et al. (2018) has investigated and developed a theoretical model of complementor's platform adoption by studying which factors play a significant role in adopting adoption. Their findings show these factors are platform features, personal elements, social engagement, and the system's environmental impacts.

The third stage is innovation development which prior studies have focused on how effectively its developers can deal with the platform (Nidumolu, 1995; Barki, Rivard, and Talbot, 2001). Factors such as their software review process or its ability to be ported to other platforms, financial benefits of developing complementary innovation, and competition in a platform have been found as critical reasons for contributing to a platform (Ghazawneh and Henfridsson, 2013; Bergvall-Kåreborn et al., 2014). Continues engagement with the end-users and developing a network effect with other developers play critical roles for complementors in the platform. Through the use of network effect theory Boudreau and Jeppesen (2015), and Kude,

Dibbern, and Heinzl (2012) also found high association involving platforms utilisation, the number of complementors, creation rates, and financial capabilities are all compatible to network effects. The findings of the Rietveld and Eggers (2018) and Yi et al. (2019) states that network value is the most common strategy applied in slightly matured platforms. Compared to newly established platforms, it contains a larger group of active complementors.

Complementor's familiarity with the platform features and ecosystem can affect their decision-making. According to Teece et al. (1997), individuals cannot adopt a complex strategy from the start. The highest level of platform ambiguity exists in "breakthrough" developments where the company would have no previous expertise or contemporary images around anything to develop. Their limited information processing skills in strategy making result from insufficient knowledge or experience regarding the event. In fact, both technological and organisational knowledge foundations are essential for reaching decisions regarding technical challenges.

Individuals' choices and decisions can be affected by their beliefs about the new technological innovation and their power to affect the decision-making process (Swan and Clark, 1992). Beliefs shape a person's view of reality by creating lenses which are used to determine evidence at the start of the decision-making process. Their view of reality influences people's perceptions and judgments. These assumptions and judgments tend to enhance the central beliefs (Swan, 1997). Therefore, complementors in one platform ecosystem can choose and apply existing knowledge while deciding what design of emerging technologies to implement. However, there has been no evidence which explains the third-party developers' beliefs and how these beliefs would lead to building strategies to create competitive advantage and success for them in a high-tech industrial platform.

Analysing beliefs could demonstrate how platforms are built to maximise complementary technical skill. Yoffie and Kwak (2006) found that valuable and successful platform governance involves a comprehensive understanding of the third-party developers and their particular attitudes and beliefs in the platform. Creating a strategic advantage ultimately requires understanding the difference in beliefs about resources' value (Barney, 1986). However, there is a lack of knowledge of how app developers' beliefs affect their strategic development and decisions to continue developing innovations in their chosen platform.

This research will analyse the latest findings into their strategic choices based on beliefs complementors formed after joining the platform and proposing a series of premises about their competitive advantage. These beliefs will be about the underlying technology and value appropriation. Also, factors such as the organisational and commercial goals of the complementors will be considered, as these factors will most likely play a role in an individual's beliefs (Ghazawneh and Henfridsson, 2013). To investigate an individual's belief system and mental models, psychological and managerial studies use 'cognition' (Rummelhart and Ortony, 1977). Through the use of cognition, researchers are able to study how individuals do deal with complex information and make sense of it (March and Simon, 1958). Chapter 3 explains the current literature on strategy and its link with cognition in management studies.

This study also concentrates on different ways complementors perform on platforms, reflecting the significance of diverse motives (Belenzon and Schankerman, 2014). It also aims to link the platform ecosystem sensemaking and new studies on the third-party developer's strategic advantage. Therefore, chapter 4 explains the current research findings on how individuals make sense of technologies using relevant mental models and schemata. Having an insightful view of the mental and information processes complementors go through to improve their innovation mechanism and strategies on the platform allows this study to create a framework for future attempts to refine their interpretation of complementary values and contributions to open platforms.

CHAPTER 3

STRATEGY AND COGNITION

This chapter aims to explain the literature review of the concepts used for this work. It provides background information regarding strategies and cognitions used by organisations and how they can be applied in practice. Through defining the critical elements of each of these subjects, it will be explained which components are suited to be applied to the notion of this study.

3.1.Strategy in Context

One of this work's objectives is to investigate each developer's cognitive strategies on a practical level. To achieve this and make the comparison much more valid, it is beneficial to use the same strategy context for the investigation and the same platform. The importance of understanding the concept of strategy has been highlighted by many researchers (Burgelman, 1983; Papadakis et al., 1998; Hambrick and Snow, 1977; Davis and Schul, 1993). The key aim of investigating strategies developed by firms has been to understand how they deal with ambiguity and the internal and external environment (Kay, 1995). The following sections explain the known concepts of strategy and which concept is linked to the notion of this study.

3.1.1. Strategy Concept Levels

The concept of strategy can be observed at many levels. In literature, strategic management and strategic marketing are discussed at a corporate, a business or a functional level (Hitt, Hoskisson, and Ireland, 2007). Corporate strategy can explain and analyse what kind of business the organisation should be involved in and how much resources should be allocated to units (Hatten, Schendel, and Cooper, 1978). At this level, entry and exit terms are often used to discuss the strategies. Potential issues like investment and acquisition are also considered since they play essential roles in advancing a corporate (Porter, 1989). As a result, decisions regarding the corporate are made at higher levels. In the concept of this work, the corporate strategy can be applied at the platform level. This strategy helps platforms with corporation direction and how different businesses can achieve a specific goal. Since we are more interested in how individual developers run their business, this strategy is not investigated further.

A level more focused than the corporate strategy is the business strategy. At this level, strategies are more focused on the competitions, both direct and indirect, within a business section. Business strategy is used to discuss how and where it is more suitable for a business to compete (Hambrick, 1980). It includes identifying the business advantages that can be used in the market to win the competition and which market they should offer their goods to have the maximum gain. To do so, customers' needs and the techniques to meet those needs should be identified.

Generally, the strategic orientation is set at the business strategy level (Camelo-Ordaz et al., 2003; Rogers, and Bamford, 2002). It is understandable since decisions regarding strategies to face competitors are made at this level. The other potential strategy available is the functional strategy. This strategy focuses on how business functions. This includes human strategy, strategies for human resources, and research and development strategies. The functional level is all about how strategies can be put in operation in each department. However, it needs to be confirmed and fixed at other high levels for a strategy to reach this level. So, it can be seen that all levels of strategies are connected up to a degree. This strategy is also not very helpful when applied to developers in comparison to the larger organisations.

Overall, this research focuses on the Business strategy, which fits its objectives more than the functional and corporate strategies. Since apps required for an open platform are innovative products, developers need to focus on improving their performance to succeed in the platform.

3.1.2. Business-Level Strategy

Business-level strategy is described as specific decisions taken by an organisation regarding its business performance in a particular sector. An organisation can have a different business-level strategy for each one of the markets it is participating. The specific elements of a firm's business-level strategy are calculated according to the scope and standards of the elements in each of its markets. Hofer and Schendel define this form of strategy as *"At the business level, strategy focuses on how to compete in a particular industry or product-market segment. Thus, distinctive competences and competitive advantage are usually the most important components of strategy at this level"* (1978, pp. 27. 28). The factors chosen to describe business-level strategy do affect on firm's overall competitive positioning.

Business-level strategy, similar to the corporate-level strategy, is able to be interpreted across a vast number of aspects. Hall and Weiss (1967) and Fisher and Hall (1969) stressed debt risk and company's uncertainties about money-generating to investigate business values. Schoeffler, Buzzell, and Heany (1974) and Schendel and Patton (1978), on the other hand, emphasised on the importance of an organisation's size and resources compared to rivals by comparing factors such as capital investment, advertising, and research. All these factors can impact the company's performance at the end.

In a market with many active organisations, the one with better strategies in the market can have better performance in the end. Therefore, strategic management research has emphasised the compatibility of business strategies with the external environment (Dess and Keats, 1987). Several research studies focus on business-level strategy and the environment (e.g. Kim and Lim, 1988; Miller, 1988). As external environments impose key challenges and uncertainties on companies, their performance is dependent on their capability to track the situations and adjust their strategies appropriately (Boyd and Fulk, 1996).

The research in strategic management states that the environment could be categorised into three components: dynamism, complexity, and hostility. Dynamism or uncertainty is linked to the speed of innovation evolvement in the market and the ambiguity of rivals' and consumers' activities (Lawrence and Lorsch, 1967; Thompson, 1967). On the other hand, complexity or heterogeneity is about the diversity across the marketplace that can push organisations to have flexibility in development and marketing tactics (Khandwalla, 1972; Porter, 1979).

A business-level strategy's effectiveness depends on the features of the market environment (Pelham, 1999). According to researchers, a cost-leadership approach is suitable for securing and stabling situations in the external market. On the other hand, a differentiation approach is suitable for dynamic and uncertain contexts in internal competitions (Porter, 1980; Jennings and Lumpkin, 1992; Kim and Lim, 1988; Miller, 1988). In situations with lower degrees of complexity and dynamism, corporations do not need to require significant fixed expenditures to maintain low production costs, and thus threats could be avoided (Marlin et al., 1994; Miller, 1986). Furthermore, companies will not require to focus on high technology improvements in these situations since the primary rivals' tactics do not often alter much (Kabadayi et al., 2007).

Companies in adverse settings must increase effectiveness to save expenses and focus less on innovation differentiation (Miller, 1991). Businesses adopting integrated strategies by merging cost management and differentiation strategies in matured sectors must monitor the surrounding environment and evaluate their existing resources (Beal, 2000). The information system literature has investigated this issue internally. For instance, findings indicate technology strategy is essential to consider when developing complementary innovation. The creation, implementation and utilisation of technology are known as the technology strategy. Strategic choices are commonly seen as guiding factors concerning scientific capacities, the complementary resources required to optimise innovation, intellectual property rights, and competitive industry conditions (Teece, 1986). It is also important to note the importance of the technology life-cycle stage (Porter, 1985). Although a plan for developing technology may be perceived as a response to a company's public and private ecosystem, it can be costly and time-consuming to gather the required data and expertise (Leonard-Barton, 1992).

Licensing strategy also distinguishes the practices of development and utilisation from those associated with technology planning and governance. Strategists have also studied it from two perspectives. These perspectives focus on either the company's strategic focus or its costs and advantages for the businesses. At the business level, the study concentrates on the time and speed that businesses take to join a platform (Lieberman and Montgomery, 1988); their ability to manage expenses to obtain the required technology (Atuahene-Gima and Patterson, 1993), developing an industry-standard or complementing established products (Lowe and Crawford, 1984).

The current literature has investigated the strategy being used in developing complementary products using quantitative analysis methods (Miric, Boudreau, and Jeppesen., 2019). However, these findings fail to explain the third-party developers' beliefs and how they would build strategies to create competitive advantage and success for them in a high-tech industrial platform. This study intends to investigate these issues by getting more in-depth insights into developers' decision-making and information processing.

3.1.3. Strategic Decision-Making

According to Bourgeois (1980), strategic decision-making can be investigated using two different approaches: the incremental-political and the rational-normative approach. The

normative perspective is part of the strategic planning school that encourages a rational strategy (Andrews, 1971, Steiner, 1969). In this approach, individuals, after analysing their organisation's surroundings, choose the most appropriate strategy (Hitt and Tyler, 1991). People first define their objectives and select the most appropriate way to attain them in a decision process. In this approach, individuals rationally investigate the options and analyse their predicted results (Bourgeois, 1980). In other words, strategic decision-making involves several reasonable, logical, and analytical procedures that employ a variety of criteria to assess strategic options (Hitt and Tyler, 1991, p. 329).

In contrast, the incremental-political viewpoint (Quinn, 1978; Braybrooke and Lindblom, 1970) is influenced by the 'Carnegie School' perspective to behavioural economics (March and Simon, 1958, Simon, 1947). This approach is generated by criticising and questioning the rational perspective to understand corporate behaviour better. As a result, this company's behavioural theory examines the cognitive boundaries of human reasoning. In this approach, individuals do not have complete information to make their decisions and search for advice. It has been mentioned by Hodgkinson and Sparrow (2002) as well: *"Actors are unable to take decisions in a completely rational manner, due to the fact that they are constrained by fundamental information processing limitations"* (p. 12). Therefore, this research follows Carnegie School's perspective as individuals search for rationality only by using their cognitive abilities (Hodgkinson and Sparrow, 2002).

3.2.Cognition and Cognitive Models

3.2.1. Cognition Definition

Knowing and becoming aware as a result of the active thinking of an individual is known as cognition. It can be considered as the opposite action of emotions. This view suggests that cognition is mainly a conscious action that limits the view obtained and criticised by Gross (2001). Although this definition separates emotions and cognition, other theories suggest that cognition is required for emotions or some form. This restricted view also does not consider that cognition can be unconscious, rapid, and irrational (Holyoak and Gordon, 1984). In this work, a broader definition was needed to overcome the issues raised here. The ideal definition should consider non-behavioural activities, unconscious, rapid and irrational thinking, which is more initiative and active. In this research, a definition was chosen to cover these points and

meet the work's objectives; so, cognition has been considered *"the mental act of using systems of assumptions and beliefs to enable individual sense-making to take place"*.

The use of cognitive strategies in theory developments requires an inclusive and broad definition. So, the new definition is much more suitable here. This definition also considers findings that showed experienced managers could use non-factual information to make an initial decision (Clarke and Mackaness, 2001). It is another advantage of this new definition, non-behavioural mental activities like intuitive thinking. Therefore, the border definition allows us to consider both analytical and intuitive thinking.

Although the literature does not emphasise the importance of knowledge, it is another factor for cognition. Bringing knowledge to the definition has its issues since it can suggest that any form of belief can be considered true beliefs. Here this can be the cause of problems as knowledge is contextual. To simplify and avoid potential confusions, "knowledge" was not mentioned in the above definition. Although some works, like Huff, and Jenkins (2002), have used their cognitive precipice of strategy, reflecting the structural relationship between factors observed in their cognitive maps. These maps were collected by their strategy sector researchers (Clarke and Mackaness, 2001). As a result, the managers acquire the form of knowledge presented here concerning the cause and effect of factors that play an essential factor for businesses success (Hodgkinson and Sparrow, 2002).

Two main points of view were identified from the previous works on organisational and management cognition (Hodgkinson and Sparrow, 2002). The first perspective is based on information processing, and the other perspective is the meaning systems perspective. The information processing perspective usually is used to study strategic management (Cyert and March, 1963; Sharfman and Dean, 1997; Miller, 1956). In strategic decision-making studies with this view, one of the main topics is the structure of cognitive models collected from managers. They tend to make the decision-making process simpler by directing and limiting the process of information available (Fiske and Taylor, 1991). The meaning system perspective is used to look at the organisations' socially constructed nature. Using this perspective in strategic decision-making makes sense of making a significant theme (Daft and Weick, 1984).

In more recent works, both types of perspectives (information processing and meaning systems) are found in the organisations, so understanding the capabilities of the strategy

domain considering both aspects is essential (Hodgkinson and Sparrow, 2002). The definition provided for cognition earlier is compatible with both perspectives.

From the application of both perspectives, it was driven that managers use the cognitive models to limit and direct the information processing and simplify the decision-making process (Senge 1990, Proac et al., 1989). These models are fundamental to managers since they represent the simplified world, and without them, there would be too much complex information for a person to process (Walsh, 1988; Daft and Weick, 1984). They can also help managers understand the environment better and decide on strategies (Day and Nedungadi, 1994; Fahey and Narayanan, 1989).

3.2.2. Cognitive Models

In this work, the 'cognitive model' term is used since it is frequently referenced in literature when focusing on individual managers' cognition (Hodgkinson et al., 2002). Frames (Shrivastava and Mitroff, 1984), Schemas (Lord, and Foti, 1986; Fiske and Tayler, 1991; Dutton and Jackson, 1987), mental models (Porac et al., 1989; Hodgkinson and Johnson, 1994), and cognitive map are the terms used in the management literature to explain cognitive models and beliefs. However, the cognitive map is more commonly used to visualise cognition (Axelrod, 1986; Daft and Weick, 1984; Fahey and Narayanan, 1989). The table below shows the terms used in this work.

Term	**Definition**	**Author(s)**
Mental Models	*"working memory updates mental models but working memory load interferes with the ability to detect slowly evolving changes. Adapting to change necessitates the detection of any discrepancy between what is currently observed and what our model predicts based on prior observations*"	Valadao et al. (2015, p. 1443)
Schemata/Schema	*"Data structures for representing the generic concepts stored in memory. They exist for generalised concepts underlying objects, situations, events, sequences of events, actions, and sequences of actions.* *Schemata are not atomic. A schema contains, as part of its specification, the*	Rumelhart and Ortony (1977, p. 101)

	network of interrelationships that is believed to generally hold among the constituents of the concept in question. *Schemata, in some sense, represent stereotypes of these concepts."*	
Cognitive Maps	*"It consists of concepts about aspects of the decision environment and beliefs about cause- and-effect relationships between them. Such maps serve as interpretive lenses which help decision-makers select certain aspects of an issue as important for diagnosis. "*	Schwenk (1988, p. 45)
Beliefs	*"a cognitive structure that represents organised knowledge about a given concept or type of stimulus [...] It contains both the attributes of the concept and the relationships among the attributes. "*	Walsh (1988, p. 874)

Table 3.1: Common terminologies used in the organisational cognition researches

To refer to the work with cognitive models of an organisation or a group of individuals, "knowledge structures" is used (Leyles, and Schwenk, 1992). Similar terms found in the literature include "heuristics and cognitive biases". However, this can confuse because heuristics can be seen as a pre-existing process, whereas cognitive bias is typically seen as a result of the cognitive models.

3.2.3. Cognitive Models and Activities

The cognitive models can be divided into two main parts. The first part corresponds to the cognitive contents, and the second part is the style or cognitive activity. A good understanding of both parts is required to get the complete image and understand the strategic orientation construct. This work is mainly focused on the content of the cognitive models. The approaches in this work use a priori assumptions in the strategy literature based on the content rather than the activities. Also, the content or assumption and beliefs are the main factors in distinguishing different ways of considering the strategy instead of cognitive activity.

In cognitive models, the content part is believed to have both the attributes regarding a stimulus domain and the relationships between them (Fisk and Taylor, 1991). In strategic management, managers' beliefs and assumptions (the attributes) are fundamental since it is believed that they

can influence performance and reduce the information processing demands (Walsh, 1988). The other important point to consider is the relationships between attributes. The structures can be based on the experiences obtained from cause-effect relationships between attributes that are important to the past's success. These could be beliefs formed due to tacit knowledge (Sparrow, 1994) or conditioned beliefs (Hall, 2002). Once applied to the cognitive models, such beliefs can help make decisions and improve the speed by limiting the available options. On the other hand, this economy can be costly, as it is built on heuristics which can influence how environments are interpreted. In turn, it can negatively affect the recognition of the changes, with only a few decision-making options available (Sparrow, 1994).

In information system studies, individuals observe emerging innovations via their internal cognitive processes and form beliefs around them. Theories such as the technology acceptance model (Davis et al. 1989) and the reasoned action theory (Fishbein et al., 1980) argue individual beliefs concerning technology usage moderate the effect of all other factors on technology adoption results. Investigations have been carried to demonstrate how prior experiences and backgrounds affect, develop, and alter cognitive beliefs (Busenitz and Barney 1997; Bryant, 2007). The cognitive beliefs of innovators are formed because of formal and informal learning through various experiences (Fiske and Taylor, 1991).

"*Perceived difficulty, adoptive experiences, suppliers' commitment to the company, perceived advantages, compatibility, and improved value*" has been identified as the internal beliefs individuals form as part of their attitude towards technology adoption. Perceived difficulty can directly have an impact on an individual's attitude toward adoption. The lower level of perceived difficulty can result in having a higher chance of adopting a technology. Prior experience with innovation can increase the chance of adopting businesses in getting essential knowledge about the technology from their users (Cusumano and Elenkov, 1994).

Research has shown that there are substantial risks associated with the adoption of the latest tech. The degree of suppliers' perceived commitment can assist with lowering the perceived risk by ensuring that enough information is transmitted from suppliers to users (Cusumano and Elenkov, 1994; Labay and Kinnear, 1981). Suppliers have the power to increase or limit their commitments in providing the required support. In the resource support domain, supporting commitments from suppliers should be particularly crucial as it could frequently impact the

capacity of the user in assimilating the technology. Furthermore, the adopter's beliefs and attitudes toward innovation can be strengthened based on the advantages it can provide for them as a perceived benefit. Benefits could be the outcome of having increased productivity, quality enrichment, lower expense, increased market dominance, emerging market creation (Naik and Chakravarty, 1992), improved work outcomes and the accompanying intrinsic and extrinsic incentives (Calantone et al., 1988).

The second part of the cognitive models was the activity component, which corresponds to managers' cognitive style that corresponds to how they evaluate and categorise the information. It is an indication of individuals characteristic and their technique in processing information (Tennant, 2019). Such activities and how processed information can be seen as a consequence of the human brain more than human experiences. Therefore, it is more stable than the cognitive content and more pre-set. Most research works in this area have focused on cognitive activity concerning the human brain. They suggested that the brain's left and right hemispheres in charge of specialisation are causing it. Neurophysiological researchers have suggested that the left sphere of right-hand side people is in charge of the analytical and rational information processing while their right-hand side of the brain is in charge of the initiative and simulative information processing (Armstrong, Allison and Hayes, 2002). So, managers' cognitive activity is believed to be based on the relation between the two hemispheres of the brains, and they are overpowering.

There have been in-depth studies of cognitive activity or style from different dimensions. Therefore, there are well developed cognitive style lists that could be used for research in strategic areas. Some of the most important ones include the initiative-thinking dimension and the adaptor-innovator dimension (Kirton, 1976). Researchers have also reported separate dimensions (fifty-four dimensions were reported by Armstrong, Allison and Hayes, 2002). Therefore, it is hard to agree on the difficulty of cognitive style or activity measurements. Theorists have suggested that using different dimensions in different works attempts to understand and study the same phenomena. For example, in Armstrong, Allison and Hayes, 2002, many individual dimensions can be grouped under 'intuitive' or 'analytical' individuals incorporated into the cognitive style index. All theorists did not welcome the idea. Hodgkinson and Sadker Smith (2003) have criticised the use of overarching dimensions. They believed Armstrong et al. (2002) approach did not cover the construct of the multidimensional cognitive

style. Hodgkinson and Sadker Smith (2003) suggested that single dimension measurements cannot show the complexity found in the cognitive style, to present that only multidimensional measurements should be used.

The independence or interdependence of the cognitive style or activity and content is a subject of discussions. It is believed that the cognitive style is not only a reflection of the cognitive activity, but it also shows some aspects of the cognitive content (Nutt, 1993). Other researchers, such as Foxall and Bhate (1993), disagree with this idea. They believe that cognitive style is only a representation of the individual's cognitive activity. It means individuals' information processing steps, cognitive activity or style, are not necessarily related to their beliefs or cognitive content. Relationships between cognitive content and cognitive activity or style are expected to be found in the strategy domain. Distinct strategy paradigms connect cognitive styles which are either more intuitive or more analytical. For instance, in the rational planning literature, analytical thinking is much more dominant. A manager can then have an analytical cognitive style and rational, analytical belief about their cognitive models' strategies. The analytical cognitive styles may influence managers and decision-makers beliefs in favour of the rational, analytical processes. The good use of the analytical approaches and techniques do encourage the employment of the analytical processes.

In studying innovation adoption, the cognitive style adaption-innovation theory (Kirton, 1976) defines a bipolar aspect with the habitual adaptor and habitual inventor at different points. A substantial number of researches indicates that some personality qualities, especially the ones which are more stable, are connected to the domain specified by Kirton's cognitive style concept (e.g., Carne and Kirton, 1982; Goldsmith, 1984; Kirton and De Ciantis, 1986). The explanation of core personality characteristics is supplemented by adaptation-innovation theory. This demonstrates that this cognitive style aspect is a product of multiple fundamental personality component qualities. Originality, the efficiency of operation, and the rule 'group conformance' were all mentioned as adequate. The consistency and repeatability of multiple component analyses agree that these core components are stable personality qualities (Kirton, 1976).

Kirton and other researchers mention dissimilarities between level or capability (of skills, talents, cognitive complexity, and intelligence) and cognitive style (e.g., Goldsmith, 1986).

Additionally, the cognitive style has been seen to be stable over time and settings (Goldstein and Blackman, 1978), and it is not dependent on both specialised training (Kagan and Kogan, 1970) and learned methods (Sternberg, 1988). What is altered, though, is the way an individual applies something he or she has learned to develop a desired behavioural reaction to environmental cues.

Works focused on other cognitive style dimensions have also indicated relations between cognitive style and cognitive content. For example, Clarke and Mackaness (2001) used cognitive content instead of cognitive style to investigate intuition in decision-making. They found that intuition can be seen in the cognitive models' content from a simplified structure as well as less factual information. There are still disagreements between scientists over intuition's possible role in decision-making and the relationships between cognitive content and cognitive style (Hodgkinson and Sparrow, 2002).

A potential issue is the fact that intuition is typically conceptualised as the opposite form of analytical thinking. Still, the reason for such conceptualisation in the strategy domain is not apparent. However, based on the cognitive style index, initiative and analytical are different and opposite (Allison and Hayes, 1996). In strategy literature, there are different forms of analytical thinking. In rational planning literature, managers or decision-makers need to investigate external trends that positively impact their organisation. But other strategy literature points to different forms of analysis with different types of analytical capabilities. It can be seen from the more interactive literature that focuses on strategic marketing. Such studies require managers to study competitors to find any potential gaps that they have not covered. Researchers that are required to understand the missing information in the data needs more intuition. These examples highlight that the initiative and analytical are not entirely separate and interrelated (Fiol, 2002).

This work mainly focuses on the use of cognitive content since, at the stage of theory development, it plays a more critical role than the cognitive style or activity. However, further research can be done to investigate cognitive styles.

3.2.4. The Stability of Cognitive Models

Cognitive styles or activities are included in the cognitive models, which makes them stable. Since managers or decision-makers methods in processing information are defined based on their brain's psychological state, having some stability is expected. But since this work focuses on using cognitive content, having stability in this content is more important. This stability is essential as it increases the predictive utility of the research.

Studies done by Hannan and Freeman (1984) have shown that organisations have difficulty adjusting to the external environment. It is a very well-known fact in strategic management studies. It has been suggested that stability can be observed in the manager's cognitive models concerning their competitive structures (Porac and Thomas, 1990; Hodgkinson, 1997). Evidence for this stability has been observed in many studies. For example, a study on the forestry products sector became apparent that no firms change their basic strategies in response to environmental changes due to their inability to cope with new conditions and different environments' views (Gronhaug and Falkenberg, 1989). Based on Sparrow (1994), having biased interpretations could result in a lack of understanding of changes, which is essential when dealing with new changes.

Longitudinal studies on the railroad sector (Barr et al., 1992) and estate agency sectors (Hodgkinson, 1997) have shown adverse effects of managers that do not change their cognitive models, in response to the new conditions, on the firm. In other longitudinal studies by Lindel et al. (1998) on a strategist in a hospital, a framework created based on a strong, stable belief and values rule over someone for a long time (in this study over three years). It has been suggested that such stability forms in the early stages of the carrier. They have also observed that situational factors can affect mental adoptions.

Based on these studies, some evidence shows that cognitive content is relatively stable, especially when considering managers' or decision-makers beliefs and values. The lack of evidence to support this idea is not due to the contradictory results obtained from different works. It is related to the lack of research works.

There is more evidence to support the idea of stability in cognitive models. However, two points need to be considered first. Firstly, these pieces of evidence are partially related to the

consistency of decision-making behaviour. It is a type of cognitive perspective and can be seen as a result of cognition instead of cognitive behaviour. Secondly, all the evidence obtained did not wholly agree with each other.

An example of this can be the work done by Dutton, Fahey, and Narayanan (1983) that suggested that the managers' decision process is influenced by different contextual factors such as motivational factors corresponding to the strategic issue managements that can be unique to each manager. Fredrickson (1985) had different views on this. His results show that contextual factors can influence inexperienced managers, but this cannot be applied to experienced ones. So, experience can play an important role in the process of decision-making. Cognitive models can change over time as managers gain more experience, But once they have built their models, they will remain consistent (Barr et al., 1992). Thus, once a cognitive model is built over a long time, it can significantly affect managers' decision-making process independent of the strategy-context factors.

To better understand the model's stability, further research is required, especially since previous works have shown some are more stable than others. The first step in such works is to improve our understanding of the cognitive models. This work also aims to help it. Comparison of cognitive models can be very challenging and requires a very systematic approach. Without an excellent cognitive model approach, a longitudinal study on models' stability cannot be done. Recently there have been significant advances in potential comparison methods, especially with cognitive mapping technique and the analysis required to study structures within maps. However, the study of other parts of maps, including their nodes and relationship, is still in the early stages of developments. One of the issues is that, in strategy domains, cognitive maps are hardly ever defined in advance. This will make it hard for researchers even to know what they are seeking. This work tries to address this issue by comparing cognitive maps of developers working on the same platforms. For this work, addressing cognition in context is very important, especially cognition needs corresponding to strategic decision-making.

3.2.5. Cognition and Decision-making:

The organisation's direction is in direct relationships with strategic decision-making (Seth and Thomas, 1994). In larger organisations, such decisions are generally made in groups, as a good understanding of the structures and systems is required to make a better decision (Hambrick

and Mason 1984). When a decision is made in a group, the difference in members' cognitive biases can help when the environment is stable. Still, it may cause problems (Miller et al., 1998). Even in groups, each member plays an essential role since they view the environments, and the problem is unique (Jackson, and Dutton, 1988). So, in an organisation, a leader's view on an issue can change the company's level. In smaller or less complex organisations, a single manager can make such decisions alone.

Previous works on managers and their roles have shown that the managers' cognition, or their beliefs and assumptions that determine their perceptions, is the most crucial factor in making strategic decisions that define its direction. For example, the lack of knowledge and perception can oversee some competitors that may significantly affect the business (Porac et al., 1989). So, having a good understanding of the decision-making is essential for having better outcomes of decisions made at the top of the organisations (Clarke and Mackaness, 2001; Hodgkinson et al., 2002).

Cognition is vital for managers, but it can also have significant effects at strategies implications level. Earlier research has shown the issues that can arise from the complexity of organisations. These results suggested that the political dimensions can result in barriers to performing new decisions made in lower levels of organisations (March and Simon, 1958; Mintzberg, 1973). It can be due to the difference in managers' beliefs in charge of implanting the idea. It is possible that each manager has perceived the new changes differently, or they have different needs based on their local conditions that result in strategies being modified accordingly (Grohaug and Falkberg, 1989). This issue has not been the focus of many researchers. In this work, the similar and different strategies used by developers are compared. It is done by investigating the cognition of individuals who are developing innovative applications for specific platforms.

Researchers also commonly use cognitive diversity to understand the impact of diversity on decision outcomes through studying cognitive processes within strategic decision-making. The vast majority of research findings aimed to investigate teams' behaviour in an organisation to understand how their decision-making would impact an organisation's overall performance. The most researched topics are linked to team performance (Liao and Long, 2016; Martins et al., 2013; Olson et al., 2007; Sauer et al., 2006), team creativity (Wang et al., 2016; Aggarwal and Woolley, 2019), team mental models (Mohammed and Dumville, 2001; Schilpzand, 2010),

and team learning. However, this theory has not been applied in the studies of outsourcing and open platforms where an organisational success highly depends on third-party developers, each separately contributing to the organisation's overall performance.

Summary

This chapter gave details on strategy and cognition literature related to managers decision-making and strategy building. As this research focuses on the complementors of the HoloLens mixed reality platform, this study follows the business level strategies of the third-party developers. Due to the newness of the mixed reality technology, no set business model would help third-party developers with product development and strategy building. Investigating the business level strategies of the complementors allows this study to look at the success factors that are helping them achieve a competitive advantage in an open platform.

Current findings suggest a wide range of factors do play key role on impacting strategies building of the businesses when developing complementary products. For an instant, ability to generate money, organisation's size and resources compared to rivals by comparing factors such as capital investment, advertising, and research have been considered effective on strategy building of developers. All these factors can impact the company's performance at the end.

In order to investigate the third-party developers' beliefs and how they would build strategies to create competitive advantage and success, the rational-normative approach has been chosen. Because strategic decision-making involves several reasonable, logical, and analytical procedures that employ a variety of criteria to assess strategic options. Developers use the cognitive models to limit and direct the information processing and simplify the decision-making process (Senge 1990, Proac et al., 1989). These models are fundamental since they can help developers understand the environment better and decide on strategies (Day and Nedungadi, 1994; Fahey and Narayanan, 1989).

This research mainly focuses on the use of cognitive content to investigate what complementors believe create success for their innovation in an open platform. However, in studying innovation adoption, the cognitive style adaption-innovation theory by Kirton (1976) have been

mostly used. Through use of this theory researchers have been able to investigate personality qualities, especially the ones which are more stable, are connected to the domain specified by Kirton's cognitive style concept (e.g., Carne and Kirton, 1982; Goldsmith, 1984; Kirton and De Ciantis, 1986). As cognitive content is embedded in schema theory (Fisk and Taylor, 1991; Harris, 1996; Lord and Foti, 1986), this study will apply this theory to investigate complementors decision-making in a new platform.

In the end, to investigate complementors decision-making in a new platform, it is essential to get a better knowledge of their beliefs about the platform ecosystem. Because these have a direct link to complementors' strategy building, since, in this thesis, complementors' decision-making about developing complementary in one platform is being studied, business-level strategies of complementors will be investigated. Complementors tend to rely on their past experiences to make sense and adopt the new atmosphere. Therefore, they must grasp the interconnections between the parts, find patterns, and draw on past knowledge to construct an upgraded perspective to take advantage of the information they have discovered. They are in a constant process of searching for information and making sense of it to deal with the ambiguity and complexity of the new ecosystem. As a result, a deep understanding of the individual sensemaking of technology is required to recognise complementors cognitive behaviour in the platform. The following chapter discusses this issue in further details.

CHAPTER 4

SENSEMAKING

This chapter discusses the concept of sensemaking and studies classifying it as a sensemaking process. As this thesis focuses on complementors sensemaking of the open platform ecosystem, this chapter discusses how mental models and schema theory have been discussed within psychology. Since the vast majority of complementors are individual developers, this chapter also focuses on current literature on how individuals make sense of new technologies and adopt them in organisations.

4.1.Sensemaking in Context

"The reciprocal interaction of information seeking, meaning ascription, and action" is how sensemaking is described (Thomas, Clark, and Gioia, 1993, p. 240). It plays an important role in shifting individual perception as a result of an unexpected occurrence (Weick, 1995). It is also considered an "*enormously influential perspective*" (Brown, Colville, and Pye, 2015, p. 2). In organisational studies, sensemaking "*lies at the very heart of organising*" (Maitlis and Christianson, 2014, p. 60). During substantial changes, how people use their cognition to evaluate the causes tend to influence their reactions. Understanding the sensemaking perspective can help discover how individuals create and develop their version of "realities" they live (Maitlis and Christianson, 2014) and react to changes.

Sensemaking can also help in better understanding of "*small-scale, local…processes by which people make sense in ways which, ultimately, are found to have profound consequences*" (Brown, Colville, and Pye, 2015, p. 273). Humans, in particular, behave based on their perceptions and understandings from past encounters as well as knowledge obtained from the outside world (Rabinow and Sullivan, 1979). Since this definition is linked to a specific action (Weick, 1995), any studies about the organisational changes require an investigation on the way that people try to understand the changes. In other words, sensemaking in organisations starts with the personal experience that a person can have to better understand the occurrence. To explain these individual perspectives, different models can be used that includes "mental models" (Daniels, De Chernatony, and Johnson 1995), "schemas" (Cossette and Audet, 1992),

"cognitive maps" (Eden, 1992), and "technological frames" (Orlikowski and Gash, 1994). The aim of this chapter is to recognise essential sensemaking viewpoints that are linked to individual decision-making.

4.1.1. Sensemaking Approach in Research Studies

People's attitudes toward change and how they tend to make sense can be grouped and studied into three different categories: macro, meso and micro (Brown, Colville, and Pye, 2015). Investigating the primary perceptions and approaches is usually the focus of macro studies, which recognises the broader discussions that researchers have about sensemaking (Brown, Colville, and Pye, 2015). It can also cover more specialist research areas, including crisis management (e.g., Maitlis and Sonenshein, 2010). Meso approach has a more focused narrative on individual sense-maker. And finally, in micro studies, the concentration is mainly on the cognitive level of sensemaking.

Weick's (1995) study has helped in forming the macro (organisational level) perspective of sensemaking, with an emphasis on public policy issues and expectations. It includes recognising what is needed to reach the result and liability and the transition towards the 'generic' structures (i.e., when members of a company substitute one another to make the most of scarce resources) (Weick, 1995).

Meso approach contradicts Weick's collective view in the macro perspective. It is used in different studies to find answers for the missing sections in the knowledge (Dervin, 1983), middle manager sensemaking (Balogun and Johnson, 2004; Rouleau and Balogun, 2011), as well as the people's perceptions of climate change (Lynam and Fletcher, 2015).

Our understanding of cognitive evaluation of knowledge structure has been based on the micro-level perspectives (Pirolli and Card, 1999; Klein and Hoffman, 2008). Example of researches that have used the micro approach is "*Supporting Cognitive Models of Sensemaking in Analytics Systems*" by Perry et al. (2009) and "*Cognitive shifts within leader and follower teams: Where consensus develops in mental models during an organisational crisis*" by Carrington and Combe, and Mumford (2019).

There is no single definition for sensemaking that fits all these three approaches perfectly. However, there is an underlying tendency to see its implementations as a way for individuals

to grasp uncertainty (Brown, Colville, and Pye, 2015). Weick developed his definition of sensemaking as "*a frame of minds about frames of mind"* (1995, p. 7) that constantly explored the sense of mismatch between expectation and experience. Snowden's (2005) sensemaking framework is used to manage a variety of different situations.

Dervin's Sensemaking (sic) takes into account how people move through dynamic and unpredictable situations, and it foreshadows a systematic approach to researching and understanding sensemaking (1983). According to cognitive researchers that study Human-Computer Interaction (HCI), sensemaking is a paradigm that seeks to describe how humans strive to discover the way that they interact with the world (Hoffman and Lord, 2013; Pirolli and Card, 2005). Authors such as Weick (1988) and Klein and Hoffman. (2008) used the term "Sensemaking" to describe evaluating knowledge to find meaning. This study adopts Weick's method by focusing on organisational and individual sensemaking to comprehend the processes involved in the development of creative products.

Weick (1995) defines sensemaking as a retrospective creation that aids humans in making sense of events through reflection. This viewpoint differs from Dervin's (1983). Individuals, he claims, are constrained to "time-space," in which everything we see or experience is fixed to our position in the temporal continuum and the time. This continuum covers the past, present, and future, all of which have an impact on how the way that an event is perceived and understood. Klein and Hoffman. (2008) also discuss how one's future can be influenced by how one thinks about and consider past occurrences. Its goal is to eliminate future ambiguity and confusion by offering appropriate options. To accomplish this, it is vital to look for relevant information, links, and hints as to how current events will play out in the future (Klein and Hoffman, 2008).

While there are obvious differences in the approaches taken in sensemaking studies and the methods used in those research, some similarities can be seen at the higher levels. For example, all of the authors recognise the temporal nature of sensemaking and its impact on the environment, whether on a social (e.g., Dervin, 1983; Snowden, 2005; Weick, 1995) or cognitive levels, as well as choosing the best knowledge structures for making the best decisions. Furthermore, academics describe sensemaking as interpretive, emphasising the mental models that humans use to build identities (Dervin, 1999; Klein and Hoffman, 2006;

Kurtz and Snowden, 2003; Russell and Pirolli, 2009; Weick, 1995). These perspectives have influenced the direction of the sensemaking process and the character and perception of research in the search for sensory actions.

This study focuses on information processing and decision-making complementors that are either single developers or part of small businesses (Miric, Boudreau, and Jeppesen, 2019). As a result, because it focuses on the cognitive appraisal of knowledge structure, the micro-level of sensemaking is the most feasible technique for this study.

4.1.2. Micro-level Sensemaking

Micro-level sensemaking in this research explains the knowledge gained in the early stages of development about cognitive studies. The human-computer interaction domain (HCI) first emerged in the 1980s (Card, Moran, and Newell, 1983) and has since been further developed as a subject (Rogers, 2012). It focuses on building artificial intelligence (AI) systems, such as computers and automated operators, on improving and manage interactions between people and different forms of machines. In management information systems, human-computer interaction (HCI) studies are "*concerned with the ways humans interact with information, technologies, and tasks, especially in business, managerial, organisational, and cultural contexts*" (Zhang et al., 2002, p. 334). Design, assessment, and performance have been the main objectives to better understand their effects in social and organisational settings. Cognitive scientists have examined and analysed sensemaking based on how people search for evidence. Cognitive models are created using information that will drive the construction of responsive artificial parts that enhance the interaction between human and computer (Klein and Hoffman, 2006; Pirolli and Card, 1999).

Artificial systems research began to improve interactions between individual drivers and artificial items, including systems required to comprehend human behaviours in social or behavioural areas. For example, issues such as people's ability to handle obstacles were significant in studying how humans dealt with dynamic artificial technology (Carroll, 2001). In addition, individual cognitive processes were studied by the cognitive science groups through tasks that could be mimicked by machines, as well as decision-making (Qudrat-Ullah, 2006) and the search for knowledge (Pirolli, 2007).

The micro-processing aspects associated with sensemaking are obtained from the examination and modelling of cognitive processes. While exploratory studies are relevant to this research programme, HCI work has already started application-focused research by building a "coherent set of theories and models" (Pirolli, 2009, p. 33). The adoption of awareness and investigative abilities requires cognitive learning. This aids in understanding and investigating how memory moves via various memory sectors in the Information Foraging Model. Cognitive learning is also involved in the development of sound behaviour enhancement technologies (Pirolli, 2014) and the implementation of an auditory recognition programme for use in ecosystems.

Model-based studies in HCI and cognitive science, in general, look at how individuals make decisions and solve problems. Models are created in this approach to recognise cognitive capacities within sensibility at a specific time. The majority of sensemaking is defined as psychological and an iterative method (Krizan, 1999) of finding the proper match between the data and the information system (Klein and Hoffman, 2006). Pirolli and Card (1999) proposed a foraging metaphor on how searching is being implemented. Using "behavioural ecology" models, Pirolli (2007) defined how people find information via web-based information.

Internet search processes such as tagging and case-based reasoning (Aamodt and Plaza, 1994) were discovered in related studies to explain cognition. Certain links have been made to comprehend how earlier experiences have affected present knowledge and sensemaking by understanding the cognitive processes employed by humans in searching for evidence. Additional studies have investigated the cognitive process required in searching in diverse circumstances (Todd and Galinsky, 2012) or the tactics used to improve memory and interactions while seeking data. However, organizational and political literature lack the insights and study models that cognitive science provides. It presents tools for analysing and acknowledging the cognitive mechanics of change, which impact any complications that arise as a result of the changes. To make sense of complementors decision-making and information processing in an open platform, this study employs schemata and mental model theories.

- Individual sensemaking in an organisation

Individuals in every organisation setting must create a sense of events happening to respond appropriately. This is especially crucial for newcomers unfamiliar with an organisation's social setting (Louis, 1980). In addition, individuals must understand organisational obstacles by

articulating complicated problems, confronting problems, and dealing with contradictions to construct more functional scenarios (Lüscher and Lewis, 2008). Individual, organisational, connection, and manager-specific tools are all available for employees to rely on to establish suitable meanings. Figure 4.1 illustrate how these factors contribute to the literature on individual sensemaking in organisations.

Resource types	Contributing factors	References
Individual Resources	• Professional self • Social-psychological self • Physiological self • Financial self • Schema; Predispositions and purposes • Past experiences • Affective status	(Bartunek et al., 1999; Gephart, 1993; Gioia & Mehra, 1996; Grant et al., 2008; Louis, 1980; Sonenshein, 2007; Weick, 1995; Weick et al., 2005)
Organisational Resources	• Functional integrity • Compliance • Style • Contextual cues • Qualities of organisational culture • Qualities of management	(Dutton, Ashford, Lawrence, & Miner-Rubino, 2002; Gephart, 1993; Grant et al., 2008; Harris, 1994)
Network Resources	• Network centrality • Proximity to power • Others' interpretations	(Ibarra & Andrews, 1993; Lockett, Currie, Finn, Martin, & Waring, 2013; Louis, 1980; Sonenshein, 2007)
Resources specific to managers	• Awareness of opportunities and threats • Organisational image and identity desired • Organisational strategies • Information processing structures	(Bartunek et al., 1999; Basu & Palazzo, 2008; Gioia & Thomas, 1996)

Figure 4.1: Factors that contribute to individual sensemaking in organisations (reproduced from Mesgari and Okoli, 2019)

Individual resources are mostly made up of the multiple selves that comprise the individual identity. Professional, social-psychological, physiological, and financial selves are examples of this that directly impact the way people make personal meaning of organisational occurrences (Gephart, 1993; Grant, Dutton, and Rosso, 2008). Moreover, current knowledge structures and mental maps as part of cognitive resources assist in making sense of an event (Bartunek et al., 1999; Louis, 1980). Individual past experiences can exist in current schemas and affect the sensemaking process (Sonenshein, 2007).

Nevertheless, to accommodate issues in management, individual schemas are being built and rebuilt repeatedly. People also tend to make sense of any variables or changes in their organisations by relying on their inclinations and goals (Louis, 1980). Furthermore, individual sense makers emotions and affective state impact the way they interpret the circumstance (Gioia and Mehra, 1996; Bartunek et al., 1999; Weick et al., 2005).

The context-specific characteristics that add to individual sensemaking processes are referred to as organisational resources. Functional integrity, conformity, and style are a few known examples (Gephart, 1993). For example, the company's fundamental objective, which must be fulfilled for the business to exist, is functional integrity. Compliance is the norms and standards that force individuals to adapt and obey; it covers regulations, classifications, and career paths. Finally, an organisation's style resource can indirectly determine the range of acceptable behaviours within the business.

Furthermore, an organisational strategy may influence the way individuals interpret new events, particularly during difficult times (Bundy and Pfarrer, 2015). Furthermore, the different context has been considered in the sensmaking process, including demographic trends, organisational cultural characteristics, and managerial attributes (Dutton et al., 2002).

Individual sensemaking is influenced by organisational culture through altering the information of individual cognitive schema. It means the organisation's general culture fosters the coherence of the majority of individual sensemaking inside a corporation (Bean and Eisenberg, 2006; Harris, 1994). While culture is considered a collective category, it can directly impact how individuals react to different situations. For example, an organisational culture in which employees actively endeavour to support one another can affect individuals' perception about the company (Grant et al., 2008).

Culture has the most significant impact in multi-national and multi-cultural organisational settings when individuals from many cultures function around each other (Shoib and Nandhakumar, 2003). Integrating cultural frames is required in this kind of scenario to allow sensemaking (Su, 2015). Individuals social network is another factor that can affect the sensemaking process, especially for people in the business industry (Weick, 1995).

Furthermore, the individuals' social network roles might alter sensemaking (Lockett et al., 2013). The stakeholders might influence people's sensemaking in the corporation they contact (Songqi Liu et al., 2015). Position-related characteristics include network relevance and closeness to power positions (Ibarra and Andrews, 1993). The more key roles people have are towards the network and connect with those who offer them access to resources, the higher their awareness would be because their social network is influenced.

Moreover, there have been resources provided expressly to managers to develop a good understanding of organisational variables. Strategic awareness of possibilities and challenges determines whether managers comprehend strategic change projects and contribute (Bartunek et al., 1999). Management needs to transform the organisation's image and identity to match with the new strategic location. It allows them to succeed in achieving the strategic transformation in companies. Managers are consequently more impacted by the intended image and identity in the process of strategic changes compared to the present ones that they are in (Basu and Palazzo, 2008).

Apart from the organisational characteristics and practices, information technologies do also impact the way managing takes place. It is done by introducing new possibilities and functionalities that enable new organising activities (Zammuto et al., 2007). As a result, technology has grown into a vital aspect of every organisational phenomenon, prompting management researchers to investigate technology sensemaking to comprehend why technology is implemented and integrated into organisational studies. Because technology is such a significant organisational phenomenon, it has become necessary to be investigated in sensemaking studies. Studies have found that individuals perceive and make sense of technology differently, especially when placed in different settings. Therefore, people and groups need to understand the technology before engaging with it. Information technology sensemaking is used when individuals and groups grow to comprehend the latest tech and assign suitable meaning to it (Gephart, 2004).

Technology sensemaking starts whenever individuals meet technological innovation or new versions of an existing one once technology inside the social system occurs. During the early stages of IT initiation and development in corporations, individuals become acquainted with the technology, form beliefs and attitudes related to it, and form opinions regarding how it may perform the job (Griffith, 1999).

Users' perceptions of innovation can affect their behaviours and their usage in the work environment (Ellway and Walsham, 2015; Yu Tong, Tan, and Teo, 2015). There have been many pieces of research that have shown signs of the massive consequences that user perception about the new technologies may have. As an example, the research conducted by Lapointe and Rivard (2005) showed indications of how different individuals adoption

behaviours can be towards a particular technology. Their findings illustrated that out of two hospitals that tested a new system, employees of one successfully adopted and used it while the other failed. This result emphasises the importance of managers learning about their user's technology sensemaking and ways to control it. As technology sensemaking is a subgroup of organisational sensemaking, it puts an emphasis on understanding the meaning of technological phenomena inside organisations (Davidson, 2006; Weick, 1990). Mesgari and Okoli (2019) categorise Technology sensemaking research in companies into three components: cognitive processes, social context, and sense giving. As this research focuses on complementors' technology sensemaking and adoption rather than how their apps get adopted by end-users, this chapter will not discuss sense giving characteristics.

4.2. Mental Models in Psychology

According to decision-making analysis, the consistency of respondents' decision-making improves as the content of conceptual, logical inference is replaced by real substance, according to decision-making analysis (e.g., Stanovich, 1999). Individuals build mental models to grasp and communicate in the external environment, rather than utilising conventional reasoning, as suggested by Johnson-Laird (1983). It enables them to consider the degree of common sense in rational thoughts. A mental model is "*a representation of the way the world would be if the premises were true*" (Byrne, 1992, p. 12). In a logical reasoning exercise, people might develop an internal model of the situation defined by the assumptions. When the substance of the premises is known, the templates can be "fleshed out" by adding more features given by the case. People make logical conclusions because their hypothesis holds in any model that can be constructed from premises. Still, mistakes can be made if they fail to recognise all possible premises models. As a result, the fewer propositional models built means fewer inference errors that people can make (Johnson-Laird et al., 1992).

Mental Model Theory helps to have a better understanding of the language used in the cognitive process. This is different from other theoretical initiatives that "*emphasise words themselves, as entries in the mental dictionary, as linked semantic entities, or rules for specifying relationships between words*" (Ehrlich, 1996, p. 224); individuals build mental models based on content, according to the notion of mental models, which emphasises the significance of words and arguments (Wason and Johnson-Laird, 1972). Aside from that, mental models share

the same relational structure as what they imitate (Johnson-Laird, 1983). Similarities to the conceptual and functional models allow individuals to perceive the meaning through mental models. Mental models are an important aspect of the ongoing scientific effort to comprehend individual brains and behaviours (Wilson and Rutherford, 1989). Based on the analogous cognitive structures, to compensate for the interpretation of facts and retrieve information, schemas can be used.

4.2.1. Schema

Schemas relate to adaptive, cognitive knowledge systems for particular ideas, persons, and events applied by people to interpret and efficiently reflect the information received (Harris, 1994). Schemata (schema) is defined as "*data structures for representing the generic concepts stored in memory. They exist for generalised concepts underlying objects, situations, events, sequences of events, actions, and sequences of actions. Schemata are not atomic. A schema contains, as part of its specification, the network of interrelationships that is believed to generally hold among the constituents of the concept in question. Schemata, in some sense, represent stereotypes of these concepts*" (Rumelhart and Ortony, 1977, p. 101). In research studies, schema can be referred to as a mental (Hodgkinson and Johnson, 1994) or cognitive framework (Walsh, 1995; Labianca, Moon, and Watt, 2005), or even a cognitive model (Ireland et al., 1987).

To understand and interpret information efficiently, people tend to use schemas related to the cognitive knowledge systems (Harris, 1994). Schemata (schema) is defined as "*data structures for representing the generic concepts stored in memory. They exist for generalised concepts underlying objects, situations, events, sequences of events, actions, and sequences of actions. Schemata are not atomic. A schema contains, as part of its specification, the network of interrelationships that is believed to generally hold among the constituents of the concept in question. Schemata, in some sense, represent stereotypes of these concepts*" (Rumelhart and Ortony,1977, p. 101). In research studies, a mental model (Hodgkinson and Johnson, 1994), mental or cognitive framework (Walsh, 1995; Labianca et al., 2005), or even a cognitive model (Ireland et al., 1987) usually are used as schemas.

A schema is a way of thinking or doing that organises groups of knowledge and their connections. People construct schemas for all life events, which helps to arrange current

knowledge in a specific field and provide a cognitive framework for absorbing new information (Fiske and Taylor, 1991). It is considered an essential basis of the cognition through which information can be processed, interpreted and understood (Rumelhart, 1980). In different instances, the schema's influences can vary, but the schema's layout remains untouched.

Hierarchical systems or communication networks can be used to organise schemas (Rumelhart, 1980). People are constantly gaining new knowledge using the existing framework that they have. If no appropriate schemata appear in the individual's mind, a new schema may be created to fit the new information. By altering the current schemata or inferring new ones, new schemata can be created (pattern recognition) (Rumelhart, 1984). Individuals can falsify knowledge if they add an inaccurate schema to a changing environment (Grunig et al., 1985).

4.2.2. Schema Theory in Management Studies

Prior researchers in management studies employed schema theory to describe cognitive issues in organisational settings (e.g., Gioia and Poole, 1984; Lord and Foti, 1986; Webb and Weick, 1979). The emphasis on schemata in recent managerial cognition research provides a more comprehensive account of how knowledge is perceived (e.g., Abatecola et al., 2018; Hodgkinson and Sadler-Smith, 2018; Mostafiz et al., 2019; Yang et al., 2019).

Wan and Chiu's (2002) study looked at incontinent schema with a higher level of creativity. In the current logical mix dilemma, the parent objects' contradicting properties can be considered a schema inconsistency. Wan and Chiu's findings revealed that completing creative tasks after confronting novel conceptual combination issues was more important than their engagement in classic conceptual combination issues. Thus, divergent thinking boosts creative efficiency by combining a variety of unique conceptual strategies.

Individuals in a corporate or company atmosphere are prone to adopting a contradictory mindset. When simultaneously perceived, paradoxical frames are recognised as descriptive models with seemingly contradictory qualities; but, when evaluated in isolation, they are considered as reasonable (Lewis, 2000). Individuals become more open to alternative possibilities and pleasant interpretations of conflicting data once they experience stress and perplexity while embracing a paradoxical framework. They frequently try to adjust their attitudes and ways of thinking to adjust to the current situation and challenge and investigate

new alternative behaviours (Smith and Tushman, 2005). The findings of various research conducted by Miron-Spektor et al. (2011) support the notion that people who use a paradoxical frame rather than another cognitive frame are more creative. Furthermore, this good relationship is assisted by a greater knowledge of conflict and greater complexity of integration, i.e. openness, open-mindedness, and adaptability.

In terms of epistemological motivation, the schema incongruity method to widening knowledge can be recognised (Carette and Anseel, 2012). Causal epistemology is concerned with the elements of knowledge such as beliefs, theories, causal inferences, behaviours, and reasons for people to recall and respond to these sources of knowledge (Kruglanski et al., 2010). Furthermore, epistemic reasons such as the need for completeness, fear of invalidity, openness to practise, and the desire for order and aversion to ambiguity can react differently depending on creative measurements.

Entrepreneurial schema theories are appropriate to this study because it focuses on third-party developers, who are typically small businesses. In entrepreneurship research, the cognitive focus is used to analyse disparities among entrepreneurs and what motivates individuals to master specific abilities or take important actions (e.g., Baron, 1998; Grégoire et al., 2011). According to schema theory, entrepreneurial alertness can help an entrepreneur to generate meaning for environmental changes by using a certain schema (using laws, relations, and classifications to translate and create meaning of new data). In addition, schema theory is particularly useful in explaining the pre-launch stage of the entrepreneurial process. This is mainly focused on identifying or developing various business possibilities (Gaglio and Katz, 2001).

- Entrepreneurial Alertness

It is a set of schemes that particular individuals embody and enables individuals to understand growth opportunities using this entrepreneurial "antenna" (Valliere, 2013). A rising amount of study on entrepreneurial awareness has found that current and prospective investors have sufficient ability to generate and operate on new ideas (e.g., Levasseur et al., 2020; Pidduck, 2020; Sharma, 2019; Srivastava et al., 2020).

According to Tang et al. (2012), entrepreneurial alertness is made up of three distinct but equally important sections. To begin with, the "scan and search" strategy encourages entrepreneurs to be persistent and creative in their pursuit of novel ideas (Busenitz, 1996). Second, entrepreneurs can generate a wide variety of database knowledge thanks to the attentiveness factor (Tang et al., 2012). Such attentiveness focuses on integrating new information in novel ways to make reasonable connections, recognise multiple options and consequences, and form unique relationships. Finally, McMullen and Shepherd's (2006) concept of first and third-party prospects applies to the "Evaluation and Judgment" scheme (Tang et al., 2012). Explicitly, this level of attentiveness is more closely linked to whether the other two characteristics ingest new information that can provide a true incentive to develop. According to Tang et al. (2012), such a system would not include the direct launch and capitalisation of an incentive unless the potential entrepreneur believes the opportunity is practicable.

A set of factors that play critical roles in building entrepreneurial alertness has also been found through different researches. The first aspect, sensing and looking for information, is critical in finding opportunities. The key parts of alertness, according to the researches, are implicit knowledge (derived from experience) and explicit knowledge (obtained from competence and information). For example, De Jorge Moreno and Victoria (2008) characterised critical entrepreneurial alertness elements as basic knowledge of the activity, managerial abilities, and professional experience. Tang (2008) has also mentioned previous expertise and experiences as possible markers. Entrepreneurial awareness, according to Valliere (2013a, 2013b), is caused by differences in the schematics and perceptual constructions that people form as a result of their background and prior learning. According to Lim and Xavier (2015), entrepreneurs should be guided by a cognitive mechanism that focuses on gathering information based on an early level of expertise and background knowledge.

Another aspect that plays a role in developing entrepreneurial alertness schemas is personality. Garcia-Cabrera and García-Soto (2016) have suggested specific personality characteristics as entrepreneurial alertness determinants. Control locus (Harper, 1998), self-effectiveness (Tang, 2008), conscientiousness (Lim and Xavier, 2015), and optimism and creativity (Ardichvili et al., 2003) are among them. Brockman (2014) believes that inventiveness is also important. According to Campos (2016), there is a promising correlation between creativity and

entrepreneurial attentiveness. It's because creativity can help to manage the passion-alertness relationship.

Social networks are also crucial since they provide knowledge and direction, which adds to the ambiguity (Tang, 2008). Khakbaz (2012) discovered that certain social network characteristics, such as the frequency of network relations, network operation, and network connections, had an impact on opportunity recognition via their effect on entrepreneurial alertness. According to Ozgen and Baron (2007), advisors, informal social networks, private business networks, and participation in technical forums can have a good impact on awareness to recognise opportunities. Ardichvili et al. (2003) identified the social network as a component determining the degree of entrepreneurial alertness in their prospective detection and growth framework as a component formed by creating relationships, cooperation, and participating in diverse activities.

Finally, the surrounding environment has been mentioned as a component. Five characteristics of the entrepreneurial environment were identified by Gnyawali and Fogel (1994). Governance policies and practices, socioeconomic conditions, entrepreneurial and market competence, and financial and non-financial support are the five pillars. Tang (2008) postulated a relation between a person's actions and their emotions. Valliere (2013) claims that heavily and customarily engaged environmental inducements to the schemata that depict future value generation highlight awareness.

Summary

This chapter sheds light on the importance of individual sensemaking in business studies. Sensemaking itself is a mechanism that incorporates cognition and behaviour to understand incidents or circumstances (Weick, 1995). Cognitive sensemaking research suggests a continuous review system involving cognition and behaviour when everyone affects a mechanism of 'enacting' that generates mutual experiences (Weick, 1979; Moez et al., 2007). The mental models, structures, or schema are drivers of this mechanism to impact the organisational participants, arranging and influencing their understanding of organisational incidents (Daft and Weick, 1984; Porac and Thomas, 1990; Gioia, 1986).

Since the focus is on third-party developers—mostly from small-sized firms—in the mixed reality platform, studying their beliefs helps to understand better the success factors in developing complementary innovation (Heinicke et al., 2016; Simons, 2000). Micro-level sensemaking has been chosen as it is mainly focused on the cognitive level of sensemaking. In general, shared mental models and team mental models are the most commonly used theories innovation development research. However, third-party developers of the chosen platform are single entrepreneurs. Therefore, these theories are not applicable and fail to capture the critical assets of the study.

According to Mesgari and Okoli (2019), professional self, socia- psychological self, physiological self, financial self, schema, past experiences, and affective status directly impact the way people make personal meaning of organisational occurrences. Individuals in a new workplace through building mental models aim to grasp and communicate in the external environment, rather than utilising conventional reasoning, as suggested by Johnson-Laird (1983). It enables them to consider the degree of common sense in rational thoughts.

To investigate complementors behaviour in an open platform and their decision-making under uncertainty, schema theory has been chosen to describe cognitive issues in organisational settings (e.g., Gioia and Poole, 1984; Lord and Foti, 1986; Webb and Weick, 1979). Entrepreneurial schema theories are appropriate to this study because it focuses on third-party developers, who are typically small businesses. In entrepreneurship research, the cognitive focus is used to analyse disparities among entrepreneurs and what motivates individuals to master specific abilities or take important actions (e.g., Baron, 1998; Grégoire et al., 2011).

Entrepreneurial Alertness as part of schema theory is a set of schemes that app developers embody. It enables them to understand growth opportunities using this entrepreneurial "antenna" (Valliere, 2013). Findings illustrate entrepreneurs/app developers goes through three elements which guids them with their decision-making to operate on new ideas. Busenitz (1996) proposed the "scan and search" strategy which encourages entrepreneurs to be determind to find and develop innovations. Tang et al. (2012) explains developers through attentiveness integrate new information in novel ways to make reasonable connections, recognise multiple options and consequences, and form unique relationships. McMullen and Shepherd's (2006) concept of first and third-party prospects applies to the "Evaluation and

Judgment" scheme. According to Tang et al. (2012), such a system would not include the direct launch and capitalisation of an incentive unless the potential entrepreneur believes the opportunity is practicable.

According to the current findings of the prior researchers in entrepreneurial alertness schemas, factors such as sensing and looking for information, basic knowledge of the activity, managerial abilities, professional experience (De Jorge Moreno and Victoria, 2008), previous expertise and experiences (Tang, 2008), and personality such as control locus (Harper, 1998), self-effectiveness (Tang, 2008), conscientiousness (Lim and Xavier, 2015), and optimism and creativity (Ardichvili et al., 2003) play a key role in decision-making.

Moreover, social networks such as frequency of network relations, network operation, and network connections (Khakbaz, 2012) provide knowledge and direction for app developers. Ardichvili et al. (2003) identified the social network as a component determining the degree of entrepreneurial alertness in their prospective detection and growth framework as a component formed by creating relationships, cooperation, and participating in diverse activities. Finally, the surrounding environment has been mentioned as a component. Valliere (2013) claims that heavily and customarily engaged environmental inducements to the schemata that depict future value generation highlight awareness.

Overall, schemes enable people to organise, arrange, and classify information into sections, reducing the need for a social-interactions-related information system (Dane, 2010; Labianca et al., 2005; Lord and Foti, 1986). In addition, schemata can instruct perception and intervention by directly acquiring and retrieving information (Harris, 1994). (Walsh, 1995; Kaplan, 2008). Therefore, schema theory can be considered as the most helpful and ubiquitous interpretation of social cognitions (Zajonc and Markus, 1985).

LITERATURE REVIEW SUMMARY AND FOCUS OF THE RESEARCH

Developers and entrepreneurs who create application and compete on open platforms encounter distinct challenges compared those who work in more traditional sectors. This thesis investigates how complexity and ambiguity of open platforms influences decisions-making tactics of complementors in app market. Figure 4.2 illustrates what stages complementors go through to develop their innovation in an open platform and what factors prior researchers have suggested which can play a role in performance of developers decisions. This diagram has been created based on the current findings of the researchers.

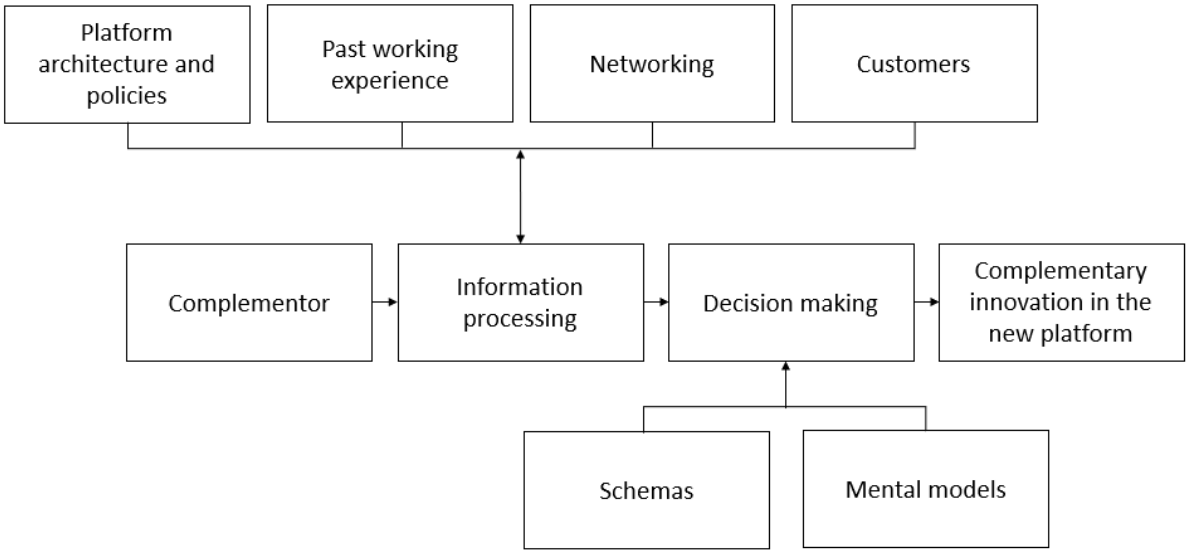

Figure 4.2: Complementors sensemaking of an open platform

Findings illustrates complementors information processing starts before joining a platform. Result of the prior study done by Rochet and Tirole (2003) shows based on how open is a platform and what policies it has around the "licensing authority" such as the IP ownership of the complements to set a number of terms for complementors to access the platforms plays a key role in their decision to join a platform. These can play a huge role when they start developing their innovations. Moreover, flexibility of technologies allow developers to easily share insights and information throughout corporate and regional borders (Teo et al., 1997-98).

Past working experience and related knowledge about the features and technologies of a new platform also effective in complementor's adoption rate. Having a greater understanding of technologies improves the understanding of future advantages and enhances the complementor's confidence (Lu et al., 2005). Although the awareness or familiarity of complementors with technologies is linked to their responsiveness to improvement, their IT and IT perception will eliminate a lousy attitude towards emerging technology or inventions (Jeong et al., 2009). More experience that familiarises complementors with existing technology allows them to assess the value of implementing emerging technologies (Bassellier et al., 2001). Complementors with a higher level of knowledge on the effects of new technologies have a higher chance of adopting them (Thong, 1999).

Continues engagement with the end-users and developing a network effect with other developers also play critical roles for complementors in the platform. Importance of network effect for enterprenuers has been emphesised in different studies. Through the use of network effect theory Boudreau and Jeppesen (2015), and Kude, Dibbern, and Heinzl (2012) found high association involving platforms utilisation, the number of complementors, creation rates, and financial capabilities are all compatible to network effects. Song et al. (2018) has investigated and developed a theoretical model of complementor's platform adoption which believes social engagement and network effect has been impacting the acceptance rate of technology and innovation (Lu et al., 2005), and it is directly related to platform adoption (Song et al., 2018).

According to Lu et al. (2005), when complementors are unsure of their capability in adopting a platform's features and technologies, they pursue advice from their group of networks involving other developers with knowledge and skills. Factors influencing individuals' social engagement, social norm, image, and behavioural intentions (i.e., beliefs and perceptions before and after adoption) play vital roles. Based on what personal characteristics of complementors have, their social engagement level also varies (Song et al., 2018).

Past studies on managers cognition illustrate goes individuals, after analysing their organisation’s surroundings, choose the most appropriate strategy (Hitt and Tyler, 1991). People first define their objectives and select the most appropriate way to attain them in a decision process. In this approach, individuals rationally investigate the options and analyse their predicted results (Bourgeois, 1980). In other words, strategic decision-making involves

several reasonable, logical, and analytical procedures that employ a variety of criteria to assess strategic options (Hitt and Tyler, 1991, p. 329).

In strategic management, managers' beliefs and assumptions (the attributes) are fundamental since it is believed that they can influence performance and reduce the information processing demands (Walsh, 1988). This research mainly focuses on the use of cognitive content to investigate what complementors believe create success for their innovation in an open platform. As cognitive content is embedded in schema theory (Fisk and Taylor, 1991; Harris, 1996; Lord and Foti, 1986), this study will apply this theory to investigate complementors decision-making in a new platform.

Entrepreneurial alertness as part of schema theory is a set of schemes that app developers embody. It enables them to understand growth opportunities using this entrepreneurial "antenna" (Valliere, 2013). This theory is suitable to this study because it focuses on third-party developers, who are typically small businesses. In entrepreneurship research, the cognitive focus is used to analyse disparities among entrepreneurs and what motivates individuals to master specific abilities or take important actions (e.g., Baron, 1998; Grégoire et al., 2011). According to schema theory, entrepreneurial alertness can help an entrepreneur to generate meaning for environmental changes by using a certain schema (using laws, relations, and classifications to translate and create meaning of new data). In addition, schema theory is particularly useful in explaining the pre-launch stage of the entrepreneurial process. This is mainly focused on identifying or developing various business possibilities (Gaglio and Katz, 2001).

According to the current findings of the prior researchers in entrepreneurial alertness schemas, factors such as sensing and looking for information, basic knowledge of the activity, managerial abilities, professional experience (De Jorge Moreno and Victoria, 2008), previous expertise and experiences (Tang, 2008), and personality such as control locus (Harper, 1998), self-effectiveness (Tang, 2008), conscientiousness (Lim and Xavier, 2015), and optimism and creativity (Ardichvili et al., 2003) play a key role in decision-making. Moreover, social networks such as frequency of network relations, network operation, and network connections (Khakbaz, 2012) provide knowledge and direction for app developers. Although this theory focuses on individual enterprenuers and how they make sense of the new changes and build

strategy for their business success under uncertainty, there is a gap in research with a focus on high-tech industries, especially app developers in a platform. Finding of this thesis will expand the area of research and indicates to what extend new findings are similar to the current literature.

Prior studies on complementors behaviour in an open platform also emphesised the importance of network effects. However, there is a lack of knowledge on how strong network effects are in a newly build open platform and what factors, other than the large number of complementary innovations, could promote competitive advantage (McIntyre and Srinivasan, 2017). This research will analyse the latest findings into their strategic choices based on beliefs complementors formed after joining the platform and proposing a series of premises about their competitive advantage. These beliefs will be about the underlying technology and value appropriation. To investigate this, an interpretative approach has been chosen to discover significance in the knowledge systems of complementors in the study and sees the world as socially formed and changeable. The findings will indicate what factors complementors believe would create success for their innovation in a new open platform.

CHAPTER 5

METHODOLOGY

This chapter provides a clear understanding of the chosen methodology based on this research's aim and objectives. The sections covered in this chapter are the philosophical approach of this research, the use of sorting technique to create cognitive maps, multiple case study, data collection processes, sample selection, validity and reliability of this research, and HoloLens as the chosen case of this study.

5.1.Research Philosophy and Design

'Research Philosophy' is usually referred to as an author's perspective and ideas about percept reality (ontological perceptions) and knowledge (Creswell and Creswell, 2018). Whereas "research design" is related to the author's overall strategy for addressing the research question(s) at hand, including the methods required to obtain and analyse the data (Saunders, Lewis and Thornhill, 2019). This chapter uses the Critical Realism (CR) philosophical approach to characterise the author's study ideology and related study design considerations. Figure 5.1 illustrates the research philosophy's layers and what has been choosing for this thesis research. As it shows, this research has an interpretive approach in which it stresses the whole nature of human perception in emergency cases (Kaplan and Maxwell, 1994).

Research layer	**Research philosophy and design decision**
Research philosophy	Interpretivist
Approach to theory development	Inductive (generate theory)
Methodological choice	Qualitative (cognitive mapping)
Research strategy	Multiple case study (embedded)

Figure 5.1: Research philosophy's layers

5.1.1. Research Philosophy Underpinning

Critical Realism (CR) is a philosophical approach which embraces the objective and interpretative perspectives of reality and is based on the presence of an organised actual world in which understanding is socially created. It separates what is considered as the "real" from

the "observable" realities. The 'real' is unobservable and stand beyond of individual understanding, theories, and interpretations. 'Observable' forms the reality, the way individuals recognise and interpret it, based on their viewpoints and encounters.

Reality is by far considered as the fundamental philosophical topic for critical realists as an organised and multi-layered ontology is necessary (Fleetwood, 2005). Reality, according to critical realists, is external and separate, yet it is not immediately reachable to us via observation and understanding. Instead of real objects, individuals perceive 'the empirical,' or feelings, which are certain representations of real things. The importance of critical realism is that it emphasises the way our perceptions may mislead us. This philosophical approach provides a solid foundation for employing a number of methodologies to acquire a deeper awareness of the meaning and value of information systems in today's society. This study takes an interpretative approach, considering app developers as individuals who create a socially created reality by joining a new innovative platform.

Bevir and Kedar (2008) argue that interpretative methods include an experience-near perspective regarding human behaviour as valuable and culturally interdependent. In other words, interpretivism is concerned with the social dimensions of an event. As the main focus of this research is to understand how complementors make sense of a new platform ecosystem, qualitative method is considered applicable to answer this question. This research identifies certain factors affecting the use of an interpretative approach, evaluated via a sensemaking lens. A variety of effects may be linked back to the foundation of sensemaking concept. The impacts come from symbolic interactionism (Burrell and Morgan, 1979), in which interpretation is perceived via a socially delineated perception of things; ethnomethodology's sensemaking processes for establishing a perception of social structure (Garfinkel, 1967; Burrell and Morgan, 1979).

The interpretative perspective, like sensemaking, aims to discover significance in the knowledge systems of participants in the study and sees the world as socially formed and changeable. Consequently, an interpretative viewpoint shapes the design of the study and represents an ontological concept of reality since socially constituted via behaviours and encounters (Orlikowski and Baroudi, 1991). A researcher develops his/her individual reality (Crotty, 1998) by engaging him or herself in the socially created world where he/she is being

placed and forming her knowledge of the factors which limit or enable her. An interpretative approach advocates people' perception of interpretation as a result of socially linked encounters. It seeks to grasp events based on the meaning attributed to them because of people (Deetz, 1996), while also studying relationships and settings (Creswell, 2008), with the understanding of diverse viewpoints might provide various perceptions of the similar information (Kincheloe, 2001). This study investigates the factors complementors believe in creating success for their product in an open, innovative platform. This approach allows research to get deeper insights on complementors strategy building based on the success factors that they believe. Past working experience and networking play a massive role in formation of these factors.

5.1.2. Approach to Theory Development

The implementation of a theory is common in scientific study (Saunders, Lewis and Thornhill, 2019). There have been two developing theories: deduction and induction (Bryman and Bell, 2011). Deductive reasoning, often known as deduction, is the process of drawing conclusions relying on broadly agreed facts or antecedents. Inductive reasoning, also known as induction, is the process of forming a conclusion solely on an observation, most commonly of a sample. An inductive approach has been chosen as this study observes complementors' cognitive behaviour after joining a new platform to understand through sensemaking of the ecosystem how they develop their innovations. Finally, this work aims to develop a conceptual framework based on data analysis results to explain the antecedents and consequences of innovation in an open platform.

5.1.3. Methodological Choice

Due to the notion of this research, which is to understand and develop a new theory, a qualitative approach was chosen to explore. Deploying a qualitative approach allows researchers to get a higher level of knowledge about the processes an organisation or a developer goes through to develop a successful product or maintain a competitive advantage. A prominent example of this is the study done by Simmons, Palmer, and Truong (2013) used a qualitative approach to get a better understanding of how organisations attempt to commercialise digital innovations. Moreover, this approach has been enabled to help the researchers with investigating humans' behaviours from the informant's perspective

(Vasconcellos, 2014). In studying managers' cognition, qualitative approaches enable researchers to investigate assumptions, values, beliefs, and motivations.

A good understanding of managers' belief and strategies is required to reach this work's aims and objectives. Such information is not easy to obtain using quantitative approaches. Since quantitative methods often deal with generalisations of the outcomes based on the study population's opinions and replies. It results in having limited findings (Barbour, 2000). In investigating an individual's cognition, a quantitative approach is used to better understand the physical, social, cultural, and linguistic environments (Langacker, 1998, p.3). In this study, a deep understanding of complementors' cause and effect beliefs and what are their objectives are required to be investigated (e.g., Calori, Johnson, and Sarmin, 1994; Kohli and Jaworski, 1990). However, these cannot be achieved by using quantitative methods. Therefore, commonly qualitative works are performed in theory-building research to address and understand causes and beliefs.

5.1.4. Cognitive Research Techniques

Due to this study's complex nature, one of the most evident issues is the higher level of interactions required between interviewer and respondent. Lack of efficient communication may cause issues if the response obtained becomes biased. The other problem that was mainly faced in this work was the need to understand and find the theories in use by managers to reach their companies' aims, as this information will not be provided just by simply asking for them (Argyris and Schon, 1974; Prahalad and Bettis, 1986).

Commonly used management research techniques are Repertory Grid, and cognitive mappings can help understand managers' belief systems (Markiczy and Goldberg, 1995). Repertory Grid helps researchers find factors that motivate the concepts used involving problem-solving by individuals in the study. Reger and Huff (1993) used the Repertory Grid techniques to apply the Personal Construct Theory in their work. Repertory Grid is helpful due to its systematic and potentially unbiased approaches that are essential compared to belief structures (Kelly, 1955; Reger, 1990).

This technique has its limitations as well. First, it is very time consuming and can board the interviewee (Brown, 1992). The other problem is performing the interviews over a long

period, especially if the interviewee is a busy complementor. This method also focuses on constructing the causes and the relations between them. Therefore, to understand the business's strategies and reach their objectives, this method is not ideal. These were the reasons for not using the Repertory Grid for this work.

On the other hand, casual cognitive focus on individuals' beliefs and the cause-effect relation (Dess and Priem, 1995). Different methods can create cognitive maps, including narrative semiotics, content analysis and argument mapping (Short and Palmer, 2008). However, in research, the most important approaches are post-hoc and interactive.

In the post-hoc approach, cognitive maps are created based on the original data obtained; this could be documents or interview transcripts. So, the maps are drawn after the events, such as the publication of papers or interviews. This method can be helpful when dealing with many cases or factors. It can also be helpful to study a case over a long period of time. Finally, the use of secondary data means this approach appears to be more economical as well. However, there are some significant disadvantages to this approach too. For example, it cannot examine the true beliefs of managers. The other issue is that the maps obtained may not be updated with the business (their factors might have changed from interviews). Based on these reasons, this approach is not suitable for this work.

The interactive approach uses real-time information that increases the data's validity (Huff, 1990), clarifies the details, and improves understanding. The most popular forms are the casual approach, 'Self-Q' technique, and the sorting technique. In this work, a technique required for comparing the cognitive structure orientations as belief structures for each manager interviewed with a high level of consistency. Such techniques can highlight similarity and difference in belief structure for the large number of interviews performed.

In initial research, loosely structured interviews were performed to allow the interviewee to cover a wide range of issues that they face. This technique was helpful to have a better understanding of the situations and explore their problems in depth. However, not having a fixed structure may cause validity problems when it comes to cognitive maps. Other problems faced was defining specific coding of responses to draw the cognitive maps and analyse the relations between factors raised during the interviews. The other factor that can influence the cognitive map was the length of the interview. It is expected that more extended interviews

that provide more information about their issues result in a more complex cognitive map, and shorter interviews would have more superficial structures. It is hard to adjust to such biases. Moreover, through interactions, there are many opportunities for other types of biases. Such reasons make this technique unsuitable for this work.

Nicolini (1999) used the 'Self Q' method to reduce researchers' effect and increase validity. To achieve this, respondents were asked to design their questions on the subject, which is also why this approach called' Self Q'. Self Q method will help create causal maps based on the interviewee's language and expression. However, this technique does not suit the current work either since using different words may affect the comparison results between cognitive maps. Although in this technique, interviewees have the freedom to choose their own words for answering the questions. However, a very strictly structured interview is required to compare maps to prevent further investigation of any issues raised (Jenkin, 1998).

The sorting technique is more suitable for having consistent results. To make a valid comparison between different beliefs, generating factors and nodes can be ideal. These can be achieved by the sorting technique. This technique's successful use in previous research has already been reported (Budhwar, 2000; Markoczy and Goldberg, 1995; Rosenberg, 1982). In this method, a wide range of factors is presented to interviewees to arrange them based on their importance. Therefore, there is no need for the researcher to be involved. This technique is much more suitable for the current study. Apart from interviewees' independence in creating their category system (Walsh, 1988), the lack of interaction between interviewer and respondent reduces potential bias. This is very important in current research that aims to develop a theory.

This technique is also useful to find theories in use by each manager. Then, different factors from theoretical beliefs are added to the list of factors presented to the interviewees. The list is presented before the interview so that they can make their choices without the interviewers. Allowing managers to think and make their decision helps to ensure results are rational and unbiased. This agrees with Kahneman and Tversky (1984) suggestion that framing biases can be reduced using techniques like cognitive mapping. When someone is asked a question, they try to reason it, which is a deliberate and effortful approach. However, initial thoughts come to mind without any search or effort. So, when they are asked to physically choose the factors,

they tend to use initiative thoughts (Kahneman, 2003). This action will help to minimise the effect of the interviewer on the results.

The systematic and consistency of this procedure is another advantage of it. It is vital when the results are going to be compared. This consistency is one of the main reasons that make this technique more suitable for current work. Other advantages of this work include being more time-efficient than other methods like Repertory Grid (Daniels, Johnson, and De Chernatony, 1994). The importance of this point becomes more evident when interviewees are going to be busy managers.

Like any other technique, this technique has its disadvantages too. Presenting a list of factors to interviews beforehand is suitable for consistency. Still, it produces some bias on the outcome since a similar construct may not even exist in this technique, more idiosyncratic using language used by respondents. Moreover, it resulted in a lack of honesty, and unscientific answers and findings can be hard to generalise. Freud (1909) and Piaget (1953) developed fundamental ideas based on a small and unrepresentative sample that were subjective and focused on the uniqueness of individual behaviours.

Nevertheless, since the comparison of the results in this work is unavoidable, this level of bias should be accepted. In this work, minimise this effect as much as possible. A large number of factors (52) were presented to each interviewee. Another issue with this technique is that researchers might look for what they want to find in response. It is crucial to eliminate this as much as possible.

To develop the sorting task, it is required to generate a pool of constructs that are potentially essential for innovation success. These factors that show app developers' beliefs about their success in the platform were generated from the literature (Markóczy and Goldberg, 1995; Walsh, 1988). Doing a small scale or trial run of a research study is referred to as a pilot study which is very helpful to prepare for the main study (Polit et al., 2001).

To study the effect of relationships between factors and the personal goal of interviewees, the laddering technique is suitable. Consistency and potentially being less biased are other factors that make this technique more ideal for this study. In addition, it is an interviewer-respond method. This means the interviewer can ask questions like why and how for each

response. This asking question is known as 'laddering up' and 'laddering down', which helps investigate consequences.

This method has its difficulties too. Like most techniques, when the focus shifts towards more personal data, obtaining other responses within the time limit may be challenging (Reynolds and Gutman, 1988). Similar techniques to Reynolds and Gutman were employed to minimise this effect. Another issue that may arise in this technique is the potential of post-rationalisation of responses provided by the interviewees. However, this is also another issue that may arise in any technique. To minimise this issue in this work, multiple research techniques have been employed. Overall, for this work, the advantages of this technique override its disadvantages. Therefore, it was used to analyse the results obtained.

A summary of the techniques introduced here are presented in the table below, which is adopted from Combe (2006):

Method	Advantages	Disadvantages	References
Loosely structured interviews	Can discuss a wide range of issues. The interviewee is free in their responses so that they can learn new issues. It can be good to get quotations from respondents.	• More opportunity to interact means a higher probability for bias. • To create cognitive maps, more interactions are required. • Less structure means the comparison of cognitive maps is more challenging.	Calori, Johnson and Sarnin (1994)
Sorting technique	Have a standard structure that makes the comparison of cognitive maps easier. Lack of interaction between interviewer and managers means less chance of bias. Time-efficient.	• The interviewer should define factors, and this can result in some bias up to a degree. • The interviewer may look for the results that they expect in the responses.	Markoczy (1997)
Self-Q technique	Interviewees decide on the questions and critical factors.	• Less structure means the comparison of cognitive maps is more challenging.	Nicolini (1999)

	Interview questions are personalised.		
Laddering technique	A well-structured method with less opportunity for bias. Helpful in investigating the consequences.	• There can be some issues in obtaining all responses required. • There is a probability of post-rationalisation of responses provided by the interviewees.	Botschen and Hemetsberger (1998) Clarke and Mackaness, 2001
Pilot studies	Identify potential problems and challenges for the main study. Simulate greater awareness about the main study. Increase the validation of the research sample.	• It can be time consuming and pricy.	Sampson (2004) Bloor (2001)

Table 5.1: Techniques in cognitive maps research studies

Based on the advantages and disadvantages presented here, a combination of sorting and laddering is chosen to analyse this data. Previous works have shown that multiple methods can be used to have a better understanding of the complementary cognitive results (Campbell and Fisk, 1959). Face-to-face interviews are also performed with the same interviewer and consistent structure.

5.2.Use of Sorting Technique to Create Cognitive Maps

As suggested in previous studies, the main difficulty in studying management of a business is finding the best technique to capture and interpret both the conscious and nonconscious cognition in and between firms in the most time-efficient manner (Hodgkinson and Healey, 2008). One of the most common methods used to overcome this is cognitive maps. Axelrod, 1976, was the first person to use this technique in his research. Since then, cognitive maps have been used as the fundamental methodology in other research in this field. Cognitive

maps are visual representations of each interviewee's cognition. However, they cannot present a complete picture. In reality, accurate maps can only exist in individual minds, but a representation of their casual relationships can be shown by cognitive maps (Nelson et al., 2000). Thus, cognitive maps can be seen as a problem-solving technique where individuals start from the current situation, which is the problem state and move towards success, which is the goal; the process of modifying the interviewee's cognitive maps is also the learning step (Cronin and Weingart, 2007).

Cognitive maps are also useful measures to see how managers operate on a day-to-day basis. To analyse these further mental models can be used. Since entrepreneurs usually work in an intuitive and uncertain environment, they may use more initiative models to develop mental models further and improve initiative models (Hill and Levenhagen, 1995).

The primary technique used to produce the cognitive maps was the sorting technique. In other research, a list of factors was produced based on factors used in similar research or interviews performed in this area. Managers are then presented with the list and asked to select essential factors before the interview. Previous research performed using this technique suggested that at least 50 factors should be presented to the interviewees to make sure they have enough choices without overloading the options for them (Markoczy, 1997; Walsh, 1988). In this research, managers are asked to select the top ten factors from their perspective. This is a good number to focus on the main factors while simplifying the process.

To help with later analysis, the production of the cognitive maps was standardised. Producing cognitive maps wholly based on the managers choice makes it more reliable. Also, through the interview process, the map is made available to both interview and managers to clarify any questions or misunderstanding. This method helps verify the accuracy of the maps created by managers and avoid performing any ad-hoc interpretation of the results (Hodgkinson, 1997).

5.2.1. Stages in Data Collections

Thirty-one app developers have been chosen for this research. An interview protocol with different stages has been developed to investigate participants' beliefs associated with information processing (Combe and Carrington, 2015). In the first stage, the sorting

technique is being used repeatedly in psychological research (Rosenberg, 1982) for drawing cognitive maps outlined by Markóczy and Goldberg (1995).

- The Sorting Task

To develop the sorting task, it is required to generate a pool of constructs that are potentially essential for innovation success. These factors show app developers' beliefs about their success in the platform and how it is related to literature (Markóczy and Goldberg, 1995; Walsh, 1988). Markiczy and Golberg (1995) methods were used to produce a list of factors:

1. A large list of factors based on previous cognitive research was produced (Buzzell, Gale, and Sultan, 1975; Markoczy,1997; Walsh, 1988).
2. The factors are then simplified. Any factors that do not apply to this work are removed. Some factors were also reworded to fit technology and app development areas.
3. Factors that reflect different belief were also left on the list.
4. The study on a small scale is known as the pilot study or the trial run to prepare for the main study (Polit et al., 2001); two pilot interviews occurred with developers in the platform to refine the factors. For the first step of pilot interviews, four developers were asked to mention the ten most essential factors they believe positively impacted their innovation's success. Also, questions related to the past work experience and skills needed to develop an app for an AR product, their motivations to contribute to product development, the stages they go through when developing a new app/product, and what can be the important factors in creating a successful product were asked too.
5. Finally, one more pilot study with two participants was conducted to check the efficiency and accuracy of the sorting factor task. They were presented with all factors selected and blank cards to add any other points they may find missing. However, the blank card was not used, and the questions were straightforward for them too.

Finally, 54 factors shown in table 5.2 were selected. It should be noted that not all these factors are investigated. This table was provided to managers to make sure they have enough options to choose the important ones. Factors that are not important can be rejected at the early stages.

Innovative idea	Market knowledge
Competitor knowledge	Unique selling point
Continually develop product/service	Feedback from consumers
Customer innovation adoption	Employees stake in the company
Identify and obtain human resources	Identify and recruit partners
Advertising	Identify distribution channel/s
Service quality	Existing competition
Design	Barriers to entry
Prototype	Trademark protection
website	Patent protection
Social media	Relationship with customers
New entrants	Clear processes
Develop a strong team	Route to market
Cash Flow	Analysis of product/service benefit
Performance metrics	Additional benefits to product/service
Balancing risk	Solving a customer problem
Support from the company	Learn from mistakes
support network	Agility
Responsiveness	Relationships with suppliers
Trial and error in decision-making	Differentiation of product/service from competitors
Personal leadership style	Personal motivation
Silo thinking	Developing staff
Planning ahead	Learning to improve
Barriers to change within the organisation	Timing of product/service introduction
Employee flexibility	Production facilities
Motivation of staff	Accessibility to resources
price	User experience

Table 5.2: Sorting factor table

5.3.Multiple Case Study

In finding the most suitable unit of analysis, it is essential to develop a research design that would thoroughly study the beliefs of individuals who have experience in developing innovation for a new platform. Multiple case studies give for a more comprehensive understanding of theoretical developments and research problems. Eisenhardt and Graebner state that this case study creates a stronger persuasive theory whenever the ideas are much more thoroughly founded in diverse empirical facts (2007). In sensemaking research studies, the case study has been used repeatedly when the aim was to investigate organisational changes (Balogun and Johnson, 2004; Gioia and Chittipeddi, 1991; Maitlis, 2005). The case study design helps develop deep, insightful, detailed, and holistic research on organisational sensemaking (Merriam, 1998). It brought a sense of versatility in the way emerging data are processed and analysed. For illustration, if the analysis requires a focus on a few particular respondents or a significant company case, then there may be more consistency in the research design (Stake, 1995, p.16).

Built on the Stake's (1995) and Yin's (2003) guideline, this research focuses on one platform only and studies its complementors decision-making after joining in and facing its new environmental challenges. This decision has serendipitously proposed a unique context in which to study managers sensemaking**.** Because high-tech platforms frequently change to keep up with competitors and customers' expectations, it would have needed a longer time to collect data for multiple case studies. As the research's main focuses are on complementors beliefs about the new innovative platform after joining in and their reasons for staying and developing other products, it is believed multiple case study would be the most suitable method to use. It offers a different perspective across the maps and additional critical informants' data (Hartley, 2004).

The evidence derived from multiple case studies is powerful and dependable (Baxter and Jack, 2008). Another advantage of using multiple case studies is that they provide a more persuasive theory since the proposals are much more deeply rooted in various factual facts. As a result, different situations allow for more exploration of research problems and theoretical progress (Eisenhardt and Graebner, 2007).

5.4.Collecting Data

Markiczy and Goldberg (1995) technique of generating cognitive maps by using the sorting technique was employed. In this technique, interviewees are asked to draw their map to speed up the process while increasing accuracy. Steps taken to create maps and collect data are as follow:

- First Stage:

The list of factors created was shared with each interviewee via Google Docs with the e-mail address (Appendix 1 and 2). Once they identified the top 10 factors in the list, they were then asked to link these factors by drawing arrows between them using Google PowerPoint online. On the top of the first page of the sorting factor file, a description was written, which guided participants on what the task asked them to do. The third point of the description had a link attached to an empty Google Presentation sheet. Participants were expected to clink on the link and draw their cognitive maps in there. As all participants were involved with building application or software programs, they had no issue filling the form. There were two further advantages in using google doc for the interviews. Firstly, google doc has an option where you can share a file with one person using their email address. This helped build and maintain trust with participants by ensuring they were the only ones accessing the file, using the link sent to them in advance.

Secondly, in a google doc, those who have access to the file can make changes and see the changes happening in the file at the same time. This option helped, especially for participants who could not work on the sorting factor task in advance or had questions from the interviewer before starting the task. Through the use of google doc, I observed participants' actions while doing the task online. The sorting factor approach is used to verify the cognitive maps' accuracy produced by participants (see Hodgkinson, Maule, and Bown, 2004). These arrows are indications of the casual relationships and the direction of such relations between chosen factors. The respondents are then asked to rank these relations' strength from -3 to +3, with one being weak and 3 representing a strong relation. So, +3 means a strong positive relation, and -1 indicates a weak negative relationship. A positive relation implies that the increase in one factor positively impacts the other point's strength. In contrast, a negative relation means by increasing one factor; the other points will decrease.

- Second Stage:

After providing interviewees with the list, enough time was given to confirm that they can create their map without any interface. Once the casual maps were created, the interviews were performed to discuss the situation in-depth. The primary study's interviews took place online via Skype due to the location of the participants.

At the start of each interview, participants were questioned about their answers in the questionnaire sent to them before the interview (Appendix 3). The questionnaire was designed to get a more in-depth insight into developers' perception of their innovation's success in the HoloLens platform. The questions related to the background information were related to job title, years of work experience, and work location to better understand the developers' working profile. The result showed that some participants could have more than one responsibility (e.g., CEO and developer). To avoid the central characters and role models in our results, the interviewing and analytical process's hierarchical structure was ignored during the data collection (Schein, 1986). Also, questions requiring short answers related to the participants' product development, decision-making, objectives, and factors influencing their innovation success were asked. Their answers allowed this study to have supportive information linked to the interview and cognitive maps' data.

Finally, the last section of the questionnaire was aimed to understand the competition in the given platform. Questions evaluate how developers perceive their innovation performance and features compared with their competitors by listing them. Overall, the information gathered from the questionnaire designed to offer additional detail to the research study.

In the second part of the interview, participants explained the reasons behind their map and decisions. The questions are open-ended, designed to find app developers' beliefs in essential factors resulting in their success. They were encouraged to explain why each factor was chosen, how this factor affected their business, and interpret their relationships. Therefore, these interviewees did not have a fixed structure, and the format depended on the answers. However, this technique was helpful in understand individual participants' cognition better and dig more into areas of complexity in each case. So, if more respondents selected the same factors, the questions asked would be identical, indicating that the interviews performed had some structures. Overall, it can be concluded that semi-structured interviews were performed, with each interview lasting at least 40 minutes.

To make sure respondents are more relaxed and confident, they were informed that their responses would be recorded and kept anonymous and confidential at the beginning of the interview. It was also indicated in the information sheet and consent form provided to them (An example of these forms is included in Appendix 4 and 5). Also, since the interviews were recorded, the interviewer did not need to take note and concentrate more on the answers and contain non-contact communications. This behaviour is essential to gain the interviewees' trust.

During interviews, the laddering technique was also used to expose participants' specific values and create more ends-meet chains (Reynolds and Gutman, 1988). The laddering technique is beneficial in exploring the main points in more detail. To start this section, interviewees were asked about their top 5 choices of the most critical factors. When the interviewer asks questions like "*why this factor is important*", he/she is laddering up the process to find consequences. While laddering down questions like "*how this is important*" helps to understand antecedents. One of the main advantages of this technique is that the interviewer asks the same question but receives different answers from participants that can reduce bias. This technique was previously used by Jenkins and Johnson (1997) to create their cognitive maps.

The top 5 factors in the laddering part of the interview complement the sorting task's results with a means-end chain. The use of 5 factors for the 31 interviewees means there could be 160 laddering responses. One hundred unique laddering responses were collected from the interviewees. In some cases, when discussing one of the top factors, the interviewee related it to the factors at the bottom of the list and explained their relation.

Audio of the interviews has been recorded and transcribed to capture and demonstrate the participants' discussions accurately. It was built on the research done by Dixon and Johnson (2011) on think-aloud rules in interviewing. They were later coded and analysed using NVivo 12 program.

This interview structure can be considered as well structured and not very flexible. However, this is essential to enable the researcher to compare a large number of cognitive maps. Towards the end, there is some flexibility in the discussions. Since, at that stage, cognitive maps are finished. Therefore, more open questions will not introduce bias to the works while

understanding the map's causal links. The protocol used can also be viewed as divergent and indirect since interviewer-respondent interaction was minimised before creating the cognitive maps.

5.5.Sample Selection

For this study, it was tried to select HoloLens app developers who already have experience developing apps. This decision helps ensure that they already have an overview of the process and its improvement. About 200 App developers were contacted through LinkedIn and invited for the interviews. Thirty-one of them accepted and participated in this research. Interviews selected have between 1 to 32 years of experience in developing software programs that helped them easier to adopt the new platform's features and ecosystem. The pie chart below shows the distribution of these participants' experience in IT-related jobs.

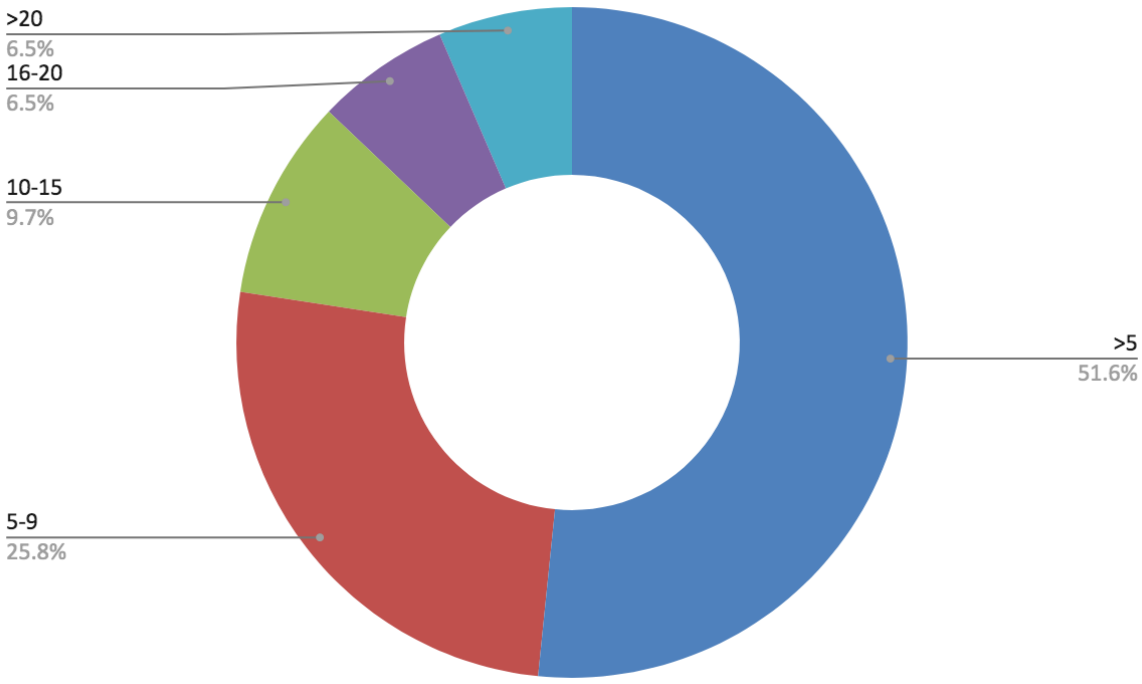

Chart 5.1: Pie charts of participants experiences

The other criteria required from interviewees were in the process of app development. Since this work aims to understand how they have dealt with uncertainty in this platform as a pioneer developer, it was vital that they currently are working. However, the area and

organisation that they work in are completely different. Table 5.3 illustrates participants information.

Participants	Gender	Country	Job title
Participant 1	Male	Sweden	Chief Executive Officer
Participant 2	Male	USA	Developer
Participant 3	Male	USA	Chief Executive Officer
Participant 4	Male	Hungary	Senior Developer
Participant 5	Male	Finland	Developer
Participant 6	Male	USA	Chief Executive Officer
Participant 7	Male	USA	Senior Software Engineer
Participant 8	Male	USA	Chief Technology Officer
Participant 9	Male	Czech Republic	Chief Executive Officer
Participant 10	Male	USA	Developer
Participant 11	Male	South Africa	Developer
Participant 12	Male	USA	Developer
Participant 13	Male	USA	Co-founder and COO
Participant 14	Male	USA	Principle Consultant
Participant 15	Male	UK	Developer
Participant 16	Male	Italy	Chief Technology Officer
Participant 17	Male	Spain	Developer
Participant 18	Male	Australia	Head of R&D
Participant 19	Male	USA	Developer
Participant 20	Male	USA	Chief Executive Officer
Participant 21	Male	USA	Chief Visionary Officer
Participant 22	Male	India	Senior Software Developer
Participant 23	Male	UK	Software Engineer
Participant 24	Male	Germany	Developer
Participant 25	Male	India	Chief Technology Officer
Participant 26	Male	USA	Chief Executive Officer
Participant 27	Female	Germany	Developer
Participant 28	Female	Norway	Developer
Participant 29	Male	France	Design Director
Participant 30	Male	Italy	Junior Software Developer
Participant 31	Male	Argentina	Developer

Table 5.3: Participants Information

This variety helps to ensure that a wide range of beliefs and challenges are considered and gives a chance to compare different strategy beliefs. Previous studies in this area have highlighted the importance of an in-depth understanding of complexity and strategies used in an organisation (Burgelman, 1983; Miller and Friesen, 1977). Therefore, to make sure the

context is standardised and valid, the HoloLens platform was chosen. It helps to focus on developers on one platform. This work design is also helpful in ensuring that the validity problems are minimised. This standardisation ensures that their strategy and methods to reach their aims are comparable to find any potential similarities and differences. However, this may also minimise the differences in their cognitive maps for this work. It was required to address the validity issue as much as possible. A similar approach has been reported in other research in this area. Narver and Slater (1990) and Combe and Carrington (2015) have chosen one organisation to focus on. This shows that this is the right approach in this area.

5.6.Validity and Reliability of The Research

Validity and reliability are essential for works that test a theory. This work aims to build a theory. The depth of understanding is much more critical. However, it has been tried to issue these concerns for current work as well.

Validity is more concerned with using the correct measures in the study. In this work, different belief structures are studied to create sorting tasks. To address validity, a large number of research papers was studied. The use of sorting tasks helps to represent the different beliefs obtained in an unbiased fashion. One of the main issues is to confirm that the results obtained are based on their belief and not anything else. Multiple data collection techniques are used to provide evidence and back up the finding to address this issue. This addresses the internal validity of the work.

External solidification is related to the generalisation of results. The approach adopted in this work is more based on the analytical generalisation instead of the statistical generalisation. It is due to that fact that the aim is to build a theory instead of testing one. To alleviate this concern, multiple respondents with set procedures were examined. More studies using higher numbers of interviewees from other innovative products are required to improve this issue further.

Reliability is more focused on the reproducibility of the same results. It can be addressed by documenting the procedures used in work, so when an auditor repeats the work, they can reach the same finding and conclusions. The use of consistent techniques helps with the reliability concerns too. Especially the sorting technique used in this work does not change

from one manager to another. A complete list of factors is also provided that can be used in future similar research.

5.7.Research Context and Case Selection

Yin (2003, p. 31) emphasises the significance of ‘bounding the case' by defining its context, type of investigation, observation units, and time and geographical bounds. This stage is critical for determining the background of the study endeavour and the evidence needed to finish it. The setting of this study is the expanding ecosystem of digital platforms, which is quickly developing and supporting numerous diverse groups of developers. As Yin emphasises, the sample population is decided by the subject under consideration (i.e., persons, corporations, initiatives and societies). In this thesis, the focus has been on complementors of the HoloLens platform.

HoloLens is believed to be the ideal platform for data collection. It is relatively new compared to other digital platforms in the market (founded in 2016). It has successfully st<UNK> its position in the market as the number one platform that offers mixed methods and augmented reality technologies. Therefore, it fits perfectly with this thesis's objective, investigating what set of beliefs complementors have about the platform in developing their innovations. Also, HoloLens seamlessly matches this research's aim to understand how complementors process the complexity and ambiguity of the new platform ecosystem and make their strategic decisions accordingly.

5.7.1. Digital Reality and HoloLens

Digital reality refers to a wide range of technologies that simulate reality in different ways, and this includes augmented reality (AR), virtual reality (VR) and mixed reality (MR). All these methods allow users to digital visual items more naturally and interactively. The term extended reality (XR) is also used to explain all forms of virtual and real interactions that allow for human-machine interaction through computers or headsets. A summary of different digital realities is shown in the table below:

Type	Definition	Example devices

Virtual Reality (VR)	An experience in a simulated world	Microsoft MR headset, Google daydream headset
Augmented Reality (AR)	Over layering reality with digital information	Mobile phones, tablets
Mixed Reality (MR)	A combination of VR and AR where users can interact and influence it	Magic Leap, Microsoft HoloLens headsets

Table 5.4: Digital Realities

Augmented reality allows users to have an interactive experience and obtain further information about their surroundings using images, sound, and text. AR is generally experienced through mobile phone and tablets. Google glasses is another example of equipment that uses AR. These glasses can display information via projectors on the user's lenses and interact with voice commands. However, they were pulled from the market by December 2015 (Empsak, 2018). The AR has expanded to mainstream technology through developers with games like Pokemon Go. Stores like Ikea and Dulux started to produce their app for their customers.

Virtual reality is an interactive experience in a simulated environment with audio and visual simulations. Other senses may also be added, including wind, temperature, and scent. The virtual world may be a simulation of the natural world, or it can be entirely imaginary. There are currently headsets available in the market that allow users to experience it; examples of these headsets are Oculus Rift and Vive Cosmos.

MR environment is where virtual and real objects are combined, given the device (Hammady and Strathearn, 2019). The MR can be seen as a mixture of VR and AR. However, it is more than that. In the MR world, action in the virtual world can affect the real world and vice versa. Statistics show the worldwide adoption and usage of MR devices is estimated to dramatically increase from 12 billion US dollars in 2018 to 192 billion US dollars in 2022, indicating an immense increase in customer's demands for MR and augmented reality (AR) devices. (Statista, 2019). Mixed reality is not deemed as a niche. Large successful technology organisations are making investments in this new technology. Google and Samsung are designing their first mixed reality goggles, and Apple owns multiple trademarks for MR goggles for smartphones (Novel, 2019). The most critical devices available in the market

that use MR are Magic Leap and Microsoft HoloLens. Developers can use these devices as plates as their platform to develop their apps. Table 5.4 shows the Most of these mixed-reality headsets do not apply to customers (they are built to be used for commercial use).

MR headsets	**Country**	**Year of release**	**Price (USD)**	**Category**
Microsoft HoloLens	US	2016	$3,000	Standalone
Magic Leap One	US	2018	$2,295	Standalone
Occipital Bridge	US	2016	$399	Smartphone
Tesseract Holoboard Enterprise Edition	India	2018	$349	Smartphone

Table 5.5: Top available mixed reality headsets according to Noble (2019)

As mentioned above, this research focused on the HoloLens platform's complementors. This platform has the best position in the market compared to its competitors and has a higher number of active complementors developing complementary innovation.

5.7.2. HoloLens Device

One of the first MR headsets that were introduced into the market was the HoloLens device. It was introduced to the market in 2016 by Microsoft. So, it is bound that this device will impact the market and the development of MR applications. This device is easy to use that does not need any external computers. The headset has a see-through display which offers a mix between physical and digital realities (Microsoft HoloLens, 2019). Developers can use this device to deploy their MR/AR applications to a growing number of customers (Graham, 2016). Since the launch of this product, many MR applications have been developed and showcased in different areas, including education, professional training, data visualisation and engineering (Microsoft HoloLens, 2019). In January 2016, Microsoft held a competition where everyone could submit their ideas for an app and vote on other ideas to gain more attention. The best ideas were then chosen by Microsoft developers to be turned into apps. The winner of this competition was the 'Galaxy Explorer' that allows users to learn more

about our galaxy. The source code for Microsoft apps is also available to developers to improve or use in their apps (Graham, 2016).

By creating app contests and awarding the winners with cash prizes ($100,000 to the top winner), HoloLens has successfully encouraged app developers to build their apps using its platform, resulting in over a thousand developers (unity3d.com, 2019). Currently, this headset targets professionals such as surgeons, engineers, designers, builders, and police and army academies (i.e., sold 100,000 units to the US Army for $479 Million) (Brustein, 2018). Motion controllers, gaze, coordinate systems, and better graphics are the critical criteria developers are interested in, allowing HoloLens to reach the market-leading position. In addition, focusing on its app developers allows this research to understand belief structure better and acts as a guide to an information domain from the early stages of product development.

- HoloLens Core Concepts

App developers need to understand a set of core concepts when developing an app for mixed reality devices. These concepts help with "*the design of immersive fluid experiences*" (Microsoft, 2019). Appendix 6 illustrates the key concepts being used by complementors of the HoloLens device, according to Microsoft (2019). Recognising the customer's point of view, arranging objects, and guaranteeing users happiness are a high priority for complementors to consider in the first stage of their product development. It is essential for developers to know and apply interaction models when developing their application for the HoloLens platform. These interaction models are voice input, having clear information about users' eye-tracking, and using hand and motion controllers of the device. Developers then must concentrate on the finer details of user interface elements and apply them to the unique environments of Mixed Reality. They also have to address basic activities, item layout, object balancing, and typography when interacting intuitively with the customers.

- Packages Used in The Platform

To develop an application for the platform, HoloLens offers a set of software programmes for developers to use. These programmes are aimed to be used for designing materials. Unity is the most commonly used program by developers, according to Microsoft (2020). It offers a number of tools to entertain and develop creative real-time 3-dimensional (RT3D)

experiences and have best practices in virtually all industries (Unity, 2020). Mixed Reality Toolkit (MRTK) is used alongside the Unity software to enter interactions like hand-tracking and eye-tracking inputs. Mixed Reality Design Labs (MRDL) is possibly the best series of open-source examples focused on Mixed Reality Toolkit - Unity (MRTK). The aim is to encourage and enable developers to create convincing and productive applications in mixed reality. MRTK includes elements in the core component, and MRDL uses these to provide further comprehensive interactions and examples. The samples are experimental/progressive, guided by experimental design that offers the designers clear evidence of quality standards for application interactions, UX and MRTK deployment. It implies MRDL is not funded by Microsoft formally (e.g., upgraded to new Unity Versions) while MRTK is represented (github.com, 2020).

- Development Policies

Microsoft has set a different number of policies that the developers and users of the HoloLens device need to follow. These policies enable the platform owner with the ability and power to strongly govern the platform ecosystem.

  - Shared Innovation Initiative

It draws on a collection of concepts that resolve coexisting infrastructure and intellectual property (IP) problems that explain and trust the client's experience with Microsoft. The initiative aims to create a dynamic equilibrium that will allow our users to expand their business via technology and encourage Microsoft to develop their platform services further. According to Microsoft, their shared innovation principles includes seven areas in which the table below demonstrates them.

Respect for ownership of existing technology	The co-creation of modern technological advances often begins from conception. Microsoft introduces its current products, IP and skills to the very same degree that its developers also show their market knowledge in their unique area. Both firms comply with the IP of each other to be eligible to co-create.
Assuring customer ownership of new patents and design rights	Microsoft would co-operate in the registration of all software patents arising from the development of modern innovation. This ensures that Microsoft will transfer all the rights, titles, and equity in the inventions they build together around the consumer.

Support for open source	Microsoft actively participant in open-source design and supports the ability to collaborate with its users to add to the project that is being co-created.
Licensing new IP rights back to Microsoft	Microsoft gives a licence on all emerging technology innovations and design rights arising from joint invention; however, the license would be restricted to developing the platform innovations. Microsoft aims to give more technical support to complementors for their business strategies.
Software portability	Microsoft does not enforce contractual limitations that prohibit third-party developers from creating new, collaborative technologies with other platforms they join.
Transparency and clarity	IP challenges could get challenging, and shared creativity will only function together when there are openness and consistency for consumers. Microsoft HoloLens platform is devoted to providing well-organised and well-defined processes that guarantee that users have clear and comprehensive details. The platform may nominate strategic sponsors to efficiently assist the patient with any issues or queries that could emerge through joint creativity work.
Learning and improvement	HoloLens is continuously improving its performance based on the feedback it is getting from customers and developers. The aim is to understand the platform members needs and provide a more significant experience for them.

Table 5.6 Shared Innovation Principles of Microsoft for its complementors

These whole initiative and ideals provide a direction that guarantees that the co-creation of emerging innovation generates additional economic value for businesses in the platform (Smith, 2018). The potential developers are encouraged to provide appropriate value by giving them proprietary rights such as copyrights, trademarks, and patents. Current platform institutional and legal studies have identified the platform's competitive threat in exploiting the importance of complementors (Gawer and Henderson, 2007; Van Alstyne and Parker, 2018) and how they should react to such behaviour (Foerderer et al., 2018; Wen and Zhu, 2019). Nevertheless, the copying or duplication of popular technologies, which may arise as rivals in the market, is a significant problem by complementors.

Digital platform complementors would use similar institutional and legal techniques frequently applied in other environments (Cohen et al., 2000). However, what specific strategies are being used vary significantly due to the sheer number of small businesses involved throughout the platforms. These different strategies will be studied through the use of the cognitive mapping technique. This study aims to map out the beliefs that developers form in the HoloLens platform and the factors they would see essential for success.

- Complementor's Issues with the Mixed and Augmented Reality Platforms

Although the mixed reality is embraced and recognised by the public, it is not performing as well as expected. Even though there is a positive perception of mixed reality devices and steady growth in the app market's investment, many of these investments may take a long time to be successful. It is partly due to the lack of a reliable business model, resulting in third-party developers facing issues choosing the right strategies to develop their products (Durbin, 2016). Except for the gaming industry, most industrial companies have difficulty relying on a business model that would be helpful with or without a mixed reality solution (Dubrova, 2019). As a result, developers find joining and developing a complementary innovation for a mixed reality platform risky.

Moreover, these platforms lack having defined app development standards (Dubrova, 2019). Due to the newness of the mixed reality concept, standards are under construction. Without these, any of these complementary innovations become scarcely compliant with the others. This makes the task of integrating alternatives to the broader unit more complex, making the eventual technical progress far slower than it should (Huang, 2017). The creation and application of technical standards have become an issue that destroys new technologies' concept. Minimising the existing errors in the platform can encourage other potential developers to join the mixed reality platforms.

Almost all complementors are inspired to join platforms due to their desire to gain advantageous value and revenue (Ceccagnoli et al., 2012; Parker and Alstyne, 2017; Gawer and Henderson, 2007). Evaluating the efficiency of sufficient value to complementors is necessary since their performance depends on their success in creating beneficial innovations (Parker and Alstyne, 2005; Boudreau, 2010). Having a greater understanding of the issues that impact complementors strategy building and their product performance allows platform owners

to identify and minimise the issues existing in the platform. Therefore, this research aims to develop a framework that would help developers understand the existing antecedent and consequences of a complementary innovation in a mixed reality platform. It will be done by identifying the beliefs and understandings of the complementors about the HoloLens platform.

Summary

Overall, four different techniques were employed to collect data. The procedure used was recommended by previous researchers, like Walsh (1988) and Markoczy and Goldberg (1995). Based on this technique, interviewees' cognitive maps are created using the sorting technique to get the top 10 factors that influence their success. Fifty-four factors were presented to interviewees to select the most important ones and identify the relationship between these points. These factors were chosen based on a pool of factors used in previous studies. Parameters related to this study were selected, and they were occasionally reworded to make them explicit.

Using sorting tasks to create top factors and then the cognitive maps, provide consistency in the results. It allows the researcher to compare the maps created directly. Any potential bias is also avoided by minimising interviewee-respondent interactions. Because interviewees are asked to draw their maps before the interview instead of the researcher creating the cognitive maps after the interview. Interviewees were also asked to fill a questionnaire before the interview. It helped to get more comprehensive details on the developers' decision-making process and their background. Finally, the laddering technique was then used to understand the factors and their relations better. It is a commonly used technique by the researchers in this area. Combining these techniques allows the researcher to get a bigger picture of the data and find any potential inconsistency. It is an essential step in ensuring the integrity of the data.

CHAPTER 6

ANALYTICAL METHOD

This chapter focuses on the chosen analytical method for this research. There is no definite analytical method to compare cognitive maps, making the task relatively tricky for this work. The method chosen needs to consider the differences between maps based on the top ten factors and the relation between them chosen by the developers.

6.1.Comparison of the Cognitive Maps

In some research, challenges compared to the cognitive maps have been discussed (Eden and Ackerman, 1998; Hodgikmson, 1997). One of the main issues is comparing the factors within the cognitive maps (Eden and Ackerman, 1998). There have been some attempts to address this issue; however, there is no perfect solution (Nicolini, 1999; Eden and Ackerman, 1998).

The stance of researchers on the use of cognitive maps is different. Some researchers believe that cognitive maps cannot examine mental structures, while others disagree with them. For example, Axelord (1976), one of the first people who developed cognitive maps, believed that these structures are primarily graphical representations. Therefore, it makes it hard to use this technique in decision-making studies. Eden (1992) was another researcher who had a similar perspective and suggested that cognitive maps cannot show what managers believe in.

Nevertheless, these researchers have used cognitive maps to help to demonstrate their discussions. In this work, the term "cognitive map" was used to address a representation of the managers' cognition, and the "cognitive model" was used to explain the cognition itself. In this work, during the interview, a representation of the developers' cognition is created. Although developers create these maps themselves in real-time and the accuracy of these results is very high, they are still only considered a representation of cognition. We then use analytical methods to compare these representations.

A common technique in comparison to cognitive maps is the distance ratio. To use this technique, cognitive maps are generally considered "hard data" that can be analysed. However, this does not hold if cognitive maps are only a representation and not the actual data.

6.1.1. Measuring Distance Ratios

A quantitative method to compare the cognitive maps is the distance ratio. This value corresponds to the highest distance score obtained from two cognitive maps. In this technique, differences between all two maps are summed up using each factor and the strength of relations between them (Langfield-Smith and Wirth, 1992). However, this method has its limitations.

Firstly, the difference between factors is set to the maximum in this approach unless identical points are chosen. It can be problematic due to the type of factors chosen in this work. For example, to address developmental strategy models, factors like 'Developing staff' and 'Learning to improve' were added to the pool. These factors are theoretically very similar; however, their scores are at the maximum distance based on this calculation. Whereas choosing these two factors can suggest a similar strategic orientation used by both interviewees, they would have completely different scores that make the comparison hard. It has been one of the main issues that make this approach inappropriate.

The other issue with this approach is the lack of order in treating the factors. In this equation, the factor's position is not essential, so the top most important factors are treated equally as the least important ones. Therefore, some of the details in the data are lost in the calculation process. Finally, this equation also considers the cognitive maps as non-cyclical. It can be problematic in the current study due to the cyclical feedback loops presented in some interviewees' maps, which is very common in casual cognitive maps (Bougon, Weick and Binkhorest, 1977). However, a complex map containing feedback loops to a simpler and linear one is not possible. These limitations have analyzed distance ratios unsuitable for current work.

All these limitations have made this technique alone unsuitable for the current work. Combining this approach with a more interpretive approach is much more suitable for this work since the method chosen should treat the data like a visual representation. Two qualitative approaches that were used in other studies are prototypical comparison and individual comparisons.

6.1.2. Prototypical Comparisons

Organisational representation is a combination of cognitive maps to create a new map. This is the main idea behind the prototypical comparison. In this method, a combination of individual

maps provides a bigger image of interviewees group like an organisation. This makes it possible to compare individuals with groups. In addition, it can help create a benchmark for comparisons (Clarke, Horita, and Mackaness, 2000). One of the most significant issues with this approach is that it creates an image for the organisation purely based on the sum of interviewed individuals' maps. It has been suggested that composite maps should only be used to set the scope and boundary of the organisation's information. There are also other issues in the creation process of the composite maps, like the need to code the individual responses collected to combine them. Also, prototypical comparisons are based on the references to a group of interviewees instead of theories (Clarke, Horita, and Mackaness, 2000; Eden and Ackerman, 1998). The categorisation in this method can exclude the external factors that impact the developer's information processing. However, developers past working experiences, the projects they are working on, and the project's stage of development impact developers' belief systems and how they would make decisions. This issue makes this technique inappropriate for the current work.

6.1.3. Individual Comparisons

This is another common technique used by researchers in this area (e.g., Clarke and Mackaness, 2001; Calori, Johnson, and Sarnin, 1994) and seem more suitable for the current work. In this approach, a visual comparison of the cognitive maps created can investigate the structure and factors' position.

Clarckson and Hodginkson (2005) made a significant contribution by creating a user-friendly software called 'Cognizer'. Previously programmes like 'Decision Explorer' and 'CMAP2' were commonly used to aid the analysis. However, older programs were not very user friendly and did not accept a large number of cognitive maps. However, like older programmes, only linear relations between factors are allowed. This was not limited to the participant when they drew their maps. Cognizer was used to help in studying the casual maps based on their structure and content in this work. The use of such programmes can help speed up the analysis stage and reduce the possibility of any human errors (Kristof-Brown and Billsberry, 2012).

6.2. Analysis of the Factors

The position of factors in cognitive maps can be used to classify them. To accomplish this, indegree and outdegree of all factors obtained in the sorting task was analysed. Here the number

of paths toward a factor is considered indegree, whereas the number of lines from a factor to others is outdegree. Therefore, it can be considered as a more systematic approach to studying cognitive maps. In these studies, the in-degree and outdegree score is the average value of the paths leading into or out of it, respectively (Pieters, Baumgarner, and Allen, 1995). Bougon, Weick and Binkhorst (1977) suggested that objectives can be identified in cognitive maps based on their in-degree scores. Factors with the highest score can be considered as the ends or objectives of each interviewee. Therefore, this method was also employed in the current work.

6.3. Cognitive Complexity

To better compare the individual maps, researchers can analyse each cognitive map's complexity. Two methods to make the comparison have been reported. The first approach analysis of cognitive categorisation was used to investigate the maps' complexity (Porac and Thomas, 1990; Dutton and Jackson, 1987). Second, cognitive complexity can be used to understand the complexity and investigate interviewees competitive structures and group them into strategic groups (Gronhaug and Falkenberg, 1989; Reger and Huff, 1993).

The other approach that can be used to investigate cognitive complexity is to study the cognitive maps directly. In this approach, the content of the map's concepts and the structural relationships between factors are analysed. Different methods are then employed to examine the complexities found. This technique helps to highlight important factors with a value corresponding to the complexity of their links. This direct measurement of complexity has made the second approach more suitable for the current work.

Other possible methods to study cognitive maps complexity, such as the strength of causal link (which can be calculated by adding up the length of chains), are more suitable for cognitive maps without any restriction. Here, interviews were restricted with the limited number of factors in the pool. So, the node ratio approach, which is not sensitive to the number of links, seems more suitable for this work (Calori, Johnson, and Sarnin, 1994). Since interviewees were asked to choose only ten factors, the number of nodes was fixed for all maps. Then it can be concluded that analysis is limited to the number of links between factors of the cognitive map.

Summary

In this chapter, a review of potential analytical methods that is suitable for this research was provided. The main method of data collection used here is the cognitive maps which are treated as a graphical representation in discussions raised. So other analytical methods are used to make measurements. One of the most common techniques to analyse cognitive maps is to measure their distance ratio. However, this requires cognitive maps to be hard data which does not apply to this work. Prototypical compression could not be used either, since a limited number of factors were given to the interviewees. So, to analyse data comparison of individual maps, the content was chosen for this work.

Several methods can be used. Firstly, the position of the factors in each cognitive map, as well as their indegree and outdegree values, can be used to classify interviewees and determine their end goal and objectives. Then, the strategy used by developers was compared to the theoretical procedures. Cognitive complexity can also help in identifying differences between each map. It should be noted that this value is limited in this work since developers were asked only to choose their top 10 factors. This affects the complexity of the final maps. But, thanks to the standardisation of the sorting procedure complexity of maps can be measured.

CHAPTER 7

DATA ANALYSIS AND FINDINGS

This chapter explains how the data collected from interviews and the cognitive maps created by participants are analysed. Secondly, it discusses the findings to answer the research questions by showing what beliefs complementors have about the HoloLens platform and its ecosystem while developing their innovations. This chapter also investigates the beliefs and their relationships to decision environments in the platform ecosystem. Lastly, this chapter also explains how these findings elaborate on the theoretical contributions that have been made in the thesis.

7.1.Data Analysis

The first part of data analysis began by importing all the interview transcribes into NVivo 12 Plus. This program can authorise a large set of data to be simplified and more easily managed during the code processings (Woods et al., 2016). This study had only one round of coding using "Theme nodes". It focuses on themes or topics mentioned in the interview, such as "factors influencing product result" or "target audiences" in the interview file. These nodes are descriptive as in the interview, participants discussed their answers to the questionnaire file and sorting factor task in the interview. Theme coding resulted in having a set of findings of the participants' target audiences, the approaches used for commercialising innovations, and factors influencing their product result in the questionnaire file. The following sub-sections discuss the findings.

7.1.1. Complementors' Target Audience

As it was mentioned in chapter 5, HoloLens only targets professionals. This decision has significantly impacted complementors ability to continue developing further complementary innovations for the platform. The most frequently mentioned theme has been companies. Most companies contacted them to develop an app, but participant 31 mentioned his projects have been with dealers that he B2B relationships with. In addition, participants 23 and 19 stated that they motivated to develop projects for the HoloLens platform from the networks they had with

other developers in the same platform. Lastly, a few developers such as participants 29 and 2 mentioned that their key driver for starting to develop an app in this platform was personal interests. However, participant 2 had the chance to take this opportunity to get more projects as the outcome of developing one successful app. Table 7.1 illustrates the themes and their frequencies linked to the target audiences notes.

Theme	**Frequency**	**Quotation**	**Synthesis**
Education system	4	*"… a lot of people…I like museum, training, education."*— Participant 29 *"I developed it first for the school my daughter goes as a fun project, but now I am working with the school and other teachers on more projects"* — Participant 2	Reasons can be based on personal interest or family-oriented motives
Other developers	6	*"other developers basically… platform is very new, and it lacks many supporting software programs and I work on that."* — Participant 23 *"I got to talk to some other developers during the time I attended HoloLens events, through chats I had with them, I got the idea to develop apps that would offer solutions to them"* — Participant 19	Motives for development came from network effects developers had
Companies	8	*"dealer… so as the dealer-based corporation, so we sell our machines to a dealer who then, in turn, sells those machines to customers and computers all over the world."* — Participant 31 *"it is construction companies."* — Participant 5 "*it's primarily for corporate users who want to kind of evaluate their meetings."* — Participant 20	Motives come from B2B contracts

Table 7.1: Complementors' Target Audience in the HoloLens platform

Prior studies indicated complememtors decision-making could differ based on how open is the platform and what policies and governance rules it sets for its third-party developers (Wessel, Thies, and Benlian, 2015). Due to the architecture of the HoloLens device, its technology and

the developed applications are only targeted towards professionals, which lowers the chance of having access to large number of users. The motivation to join a platform from past working experience is in line with the findings of the Song et al. (2018), which believes social engagement and network effect has been impacting the acceptance rate of technology and innovation (Lu et al., 2005) as well as the network connections elements in the entrepreneurial alertness theory (Khakbaz, 2012). These findings state that through network effect, complementors can improve their knowledge and direction in a new platform and under uncertainty.

7.1.2. Commercialisation of the Apps Developed in HoloLens Platform.

Participants mentioned that they value both online and offline techniques to commercialise their app. Developers who used online techniques like on Facebook, LinkedIn, or opening and running their personal website. Findings illustrates having an active website is the most critical way to both commercialising the apps that they have developed and showing their online presence to the market. Table 7.2 shows a sample of analysis done using NVivo 12 to investigate which online technique has been used more frequently.

Theme	**Frequency**	**Quotation**	**Synthesis**
Online	19	*"our strategy has been maintenance of our own websites, use of LinkedIn views of Facebook and use of YouTube really. These have been the four most useful things we've done."* — Participant 18 *"we have several things that is pending because they need to be approve for basically marketing this particular thing online. And it's really got targets like it's got a very specific target audience. So eventually we will have highlights on arc on the client's website which is the Menomonee site. We'll have highlights on our website and then we will release the co case study with them. Basically, going how it's having an impact educationally on the client. So, most of that is pending at this point as I noted in each of those questions."* — Participant 21	LinkedIn, organisation websites, social media platforms (Facebook), and YouTube have been mentioned by developers repeatedly.

		"*I would say on social media and that's quite all. We have a website or so but I think those two are the main."* — Participant 29	
Offline techniques	18	*I attended two public demonstration and meet ups and that's it. I tried it the public demonstrations meetups. It is where people could get together and talk about technology. I was able to get to know some other developers like me and exchange contact with them"* — Participant 10 *"It would be just the network of people who the marketing people know who the higher-ups know so if they know people at big companies that that they can go, and talk do they have their connections. So, it's not so much word-of-mouth or round the majority of people but more connections at the very the CEO level connections that people make… I'm comforted at exhibitions the company that I work for went down to future decoded in London and had installed there so there was plenty of mingling and network working going on at events like that."* — Participant 15 *"It mostly comes down to our conferences and our speaking… having face-to-face conversations, you know, meeting over lunch or coffee swapping information um giving demonstrations to each other and yeah occasionally as well assisting with technical difficulties or swapping tips and tricks ."* — Participant 18	Attending exhebitions, events, and workshops has been the most impactful way to promote their finished apps, show their prototypes and get some feedbacks form others, and networking with other complementors in the same industry.

Table 7.2: Techniques used by complementors for commercialising their apps.

Developers also emphasised the importance of using offline techniques to increase the market's knowledge about their products. Unlike the online presence that has been used to get more customer knowledge about their innovations, an offline presence like attending exhibitions, conferences, and events is mostly popular for networking with other developers and getting feedback on the projects they are working. This finding is consistent with the prior research by

Boudreau and Jeppesen (2015) in which it emphesis developers to minimise the chance error and improve their performance in a platform search for networks with other developers in the same platform.

7.1.3. Factors Influencing the Product Result

During the interview, participants were asked to name the top three factors they believe influence their product result in the HoloLens platform. Overall, 17 factors were mentioned: customers, staff knowledge, and money were the top three answers. Table 7.3 shows the key elements mentioned by participants regarding these three points.

Factors	**Frequency**	**Description**
Customers	20	• Customers drive the product. • Importance of having user experience. • Importance of ability to understand and adopt the technology. • Importance of meeting their expectation to complete the application. • Importance of meeting needs and solving their problems.
Staff knowledge	17	• They play a key role in developing an innovation that would meet customers' expectations. • Staff knowledge and experience can speed up the process of software adoption and product development.
Money	8	• It correlates with the features that can be bought to develop a more advanced application. • It is linked to forming a strong team and the number of hours developers would spend working on the project.

Table 7.3: Top three factors that have an impact on product result according to participants.

Findings of this study illustrate customers are placed at the centre of the projects as their satisfaction can lead to having a complete and successful project. To make that happen, developers have focused on developing several prototypes tested by customers regularly. Based on the feedback developers receive, they move to the next stage of the development. Therefore, developers constantly try to check if the technologies added to the project are adoptable by customers and understand how to use it. It is beneficial for complementors to develop a product for a customer who has a certain level of user experience to understand the HoloLens hardware

and software features. This way, customers can give more explicit instructions on how they want the final product to look. Constant communication with customers and developing prototypes significantly impact final product success. The following quotations support these statements.

"it's about solving a customer problem. They need something particular, and we are working on that. It's like the right idea of customers need; it's definite. We have specific customers from our new car engineering and aerospace; they are very different from others. Meeting customers' expectations overall significant" — Participant 9

"We want our application to be accessible, so we are really user-driven. So their needs are really what is at the heart of our development. We are a small team, and everyone has a good impact on the project. And we are open to everyone's ideas even if, in the end, the public and customers matter the most. But we communicate a lot, and we have involved in the development of the decision we make on the project." — Participant 29

"I mean user experiences. this is very important because it determines how people will interact with your app so your product result if it has a poor user experience and you know it may be a great product but if these are experiences really poor and people are going to have a hard time using it so even though if the product works well if it's not easy to use then it'll result and a hard to use product which will be difficult to have but adopted visuals you know if it's not." — Participant 10

Although the importance of end-users for platforms and complementors have been mentioned in prior studies such as Chellappa and Saraf (2010), the findings of this study highlight a different aspect of the importance of the end-users and add new insights into the current knowledge on customers of open platforms. Due to the structure of HoloLens, complementors depend on the end-users and their continued contribution to the development of applications from the beginning of production. As each product is targeted towards one customer or one company, interaction with customers plays a massive role in the application's performance. The constant communication and connection with the particular customers result in the lowest chance of product failiture in this platform than any other open platform.

Staff knowledge is another factor that developers have repeatedly mentioned as an influential factor that can impact the process of product development. As participants 15 and 21 mentions below, due to the newness of the platform and the technology it offers, most developers do not have prior experience that would fit this platform expectations. Therefore, having a staff member in the team who knows how to work with the hardware and software system of HoloLens, can speed up the process of product development.

"*Because the conservatively new sector and not many people have experienced […], it was fortunate that I had some experience with the Unity/the Unity game engine beforehand which is what is used for HoloLens development […] what makes all with HoloLens development a lot easier but in the whole sector […] there are very few people who are experienced*." — Participant 15

"Customers don't know what to expect to such they're being promised many things but they're not aware of what will help them and what will not at this stage […] the ones with a knowledge of that and the ones who can choose which direction to go in and how to make things better are other people creating the app of this right now right and people with the knowledge of what works and what doesn't more than a customer currently knows." — Participant 17

"Because the employees […] the customer has a general idea of their problem, but they don't know how to solve it, so the employees are the creative engines to solve the problem basically." — Participant 21

According to prior findings of Teece et al. (1997), humans cannot implement a complex strategy right away. The most significant proportion of platform uncertainty may be seen in "breakthrough" technologies, in which the corporation has no prior experience or current imagery to work with. Poor knowledge or experience with the incident has resulted in their poor information processing skills in plan formulation. In reality, for making judgments on technical difficulties, both technological and organisational knowledge foundations are required. This is in line with the findings of this study as participants of this study emphasise the difficulty of adopting the platform technology at the beginning and the need to have a knowledgeable colleague. This shortens the information processing stage and helps developers make more effective decisions (Yoffie and Kwak, 2006).

Lastly, several developers have mentioned money as a key factor that can make the process of development and adoption easier. As it has been mentioned by participant 15, receiving a massive fund from customers or sponsors do help developers with getting access to more software and hardware features and developing more advanced projects. Moreover, with this money they receive, they can recruit more knowledgeable staff to speed up development.

"There is the amount of money that the companies are interested in providing for the product so I'm whether that limit everything from the team size to the amount of time we can spend on it and it limits the scope of the entire project really." — Participant 15

"*Microsoft released some new updates right up there that could use that cost, but you still need a really good internet connection in order to do those work [...] a certain level of polygons all the way down to the 250 or so thousand thresholds that the HoloLens requires from the polygons required for the polygon number so that becomes very expensive and it is not possible to purchase that just to develop a more advanced product*." — Participant 31

Overall, this section aimed to get background insights about participants and their approaches to developing a HoloLens platform. Their background experiences showed that many joined this platform knowing their background experience as developers help them adopt this innovative platform, which is linked to their motives in gaining more knowledge and experience in the innovation field. This is in line with the findings of Harper (1998) and Tang (2008), which indicate previous expertise and experiences do play a key role in managers decision-making.

Many joined this platform due to a request from their customers to develop a mixed reality app. Also, one participant joined the platform for fun at first but then got involved with developing more serious apps as the result of receiving requests from others (participant 2). This points out the importance of having access to customers, which has been mentioned as the number one influencing factor on product result. It shows elements mentioned are linked to each other and can have an impact on one another.

This section also looked at how participants try to commercialise their innovations in a market where the target audience are all professionals. The online techniques used, such as creating a website or opening an account on social media, improve their customer awareness level.

Offline techniques like exhibitions and events are mostly used for networking and getting feedback on their projects. These offline techniques are the best way to meet professionals with a high level of knowledge and skills in the information system sector. It is a great opportunity for those who are not financially capable of adding more staff to their team and need other's opinion on how to improve their projects or tackle an issue.

The findings of this section provided a clear view of the process developers goes through to develop their product. Knowing these findings was necessary for this study before moving to the cognitive mapping section. Since section 7.2 only focuses on developers beliefs and how these beliefs can lead to innovation success.

7.2.Cognitive Mapping Analysis

Each hand-drawn map was transferred into the "Cognizer" program (Clarkson and Hodgkinson, 2005). As mentioned in chapter 6, this program provides several calculations on standardised casual cognitive maps, first presented by Markóczy and Goldberg (1995). The findings are set for further statistical analysis similar to data analysis done by Markóczy (2001).

7.2.1. In-Degree and Out-Degree Analysis

The next data analysis stage is to study the cognitive maps based on the factors and their relationships. This allows a more detailed analysis using in-degrees (or how many links are coming into a factor) and out-degrees (or how many links are going out of a factor) (see Bougon et al., 1977). Understanding in-degree factors allowed this study to look at the app developers' objective or strategies believed to be the most important (Swan and Nowell, 1994). Out-degree looks at the factors developer believe have an impact on their decision-making. Out-degree is a measure of the total of relationships from a factor in the map to other factors. It is also a calculation of how significant the factor is to create an impact on other factors. Higher scores show the significant power of that factor in causing a change in other variables. The in-degree and out-degree values presented in the following table was calculated by adding the strengths of the relationships and the rank is the average rank of the value concerning the complete list.

The demographic representations of the values are shown below.

Number	Factors	Id	RK	Od	RK

1	Innovative idea	32	5	28	7
2	Market knowledge	13	15.5	53	2
3	Competitor knowledge	4	35.5	-1	51
4	Unique Selling Point	11	17	9	18.5
5	Continually develop product/service	18	9.5	25	8
6	Feedback from consumers	14	14	13	13
7	Customer innovation adoption	10	18	16	10.5
8	Employees stake in the company	0	49	0	45
9	Identify and obtain human resources	7	25.5	8	22.5
10	Identify and recruit partners	6	29	6	28.5
11	Advertising	9	20	15	12
12	Identify distribution channel/s	21	7	0	45
13	Service quality	30	6	8	22.5
14	Existing competition	0	49	6	28.5
15	Design	35	4	10	15.5
16	Barriers to entry	2	42.5	-4	53
17	Prototype	17	12	16	10.5
18	Trademark protection	0	49	0	45
19	web site	5	32	0	45
20	Patent protection	2	42.5	0	45
21	Social media	3	39.5	2	36.5
22	Relationship with customers	56	2	42	5
23	New entrants	0	49	0	45
24	Clear processes	5	32	7	25.5
25	Develop a strong team	39	3	58	1
26	Route to market	13	15.5	3	33.5
27	Cash Flow	7	25.5	2	36.5
28	Analysis of product/service benefit	18	9.5	9	18.5
29	Performance metrics	7	25.5	6	28.5
30	Additional benefits to product/service	1	44	0	45
31	Balancing risk	4	35.5	11	14
32	Solving a customer problem	61	1	47	4
33	Support from the company	-11	54	30	6
34	Learn from mistakes	16	13	3	33.5
35	support network	8	22.5	9	18.5
36	Agility	9	20	24	9
37	Responsiveness	9	20	5	31.5
38	Relationships with suppliers	3	39.5	10	15.5
39	Trial and error in decision-making	0	49	0	45
40	Differentiation of product/service from competitors	18	9.5	9	18.5
41	Personal leadership style	5	32	50	3
42	Personal motivation	7	25.5	5	31.5
43	Silo thinking	0	49	-5	54
44	Developing staff	4	35.5	7	25.5
45	planning ahead	18	9.5	8	22.5

46	Learning to improve	6	29	6	28.5
47	Barriers to change within the organisation	0	49	2	36.5
48	Timing of product/service introduction	8	22.5	8	22.5
49	Employee flexibility	3	39.5	2	36.5
50	Production facilities	0	49	0	45
51	Motivation of staff	6	29	1	39
52	Accessibility to resources	4	35.5	0	45
53	price	0	49	-3	52
54	User experience	3	39.5	0	45

Table 7.4: Etiographic representations of app developers

The analysis shows "solving customer problem", "relationship with customers", and "develop a strong team" are the most important objectives to the app developers with the highest in-degree scoring of 61, 56, and 39. Solving customers' problem and building a strong positive relationship with them have allowed developers to increase customer's satisfaction and build a positive reputation in the platform and continuously develop a more functional app with the minimised level of error in its performance. Having a strong team is relatively crucial to the developers since this is a new platform and requires a fast adoption of the system. Recruiting partners with working experience in similar platforms allow developers to minimise time spent learning new programs like Unity to create MR and AR apps. Due to the low number of customers, the competition is mainly between the app developers rather than the products. Bellow are example quotation from leaders.

"For particular HoloLens platform, major skills required like 3D modelling and 3D graphics […] particularly gaming/3D gaming as it is very different and much more visual compared to other platforms, so having a background in working with these programs is helpful in the development process." —Participant 11

"I believe customers play an important role in the success of a product. Being able to understand their issues and resolve them is very important. This can mean collaboration with other developers to create a better and stronger app." —Participant 21

Consequently, the differences and similarities between the app developer's beliefs mainly do form around their work experiences and customers. Furthermore, due to the newness of the platform, app developers must have a specific set of skills to join the platform. As a result, based on the availability of customers and their expectation from the app during the

development of the product and the app developers' knowledge about the device and its software programs, beliefs can differ from one developer to another. These findings emphasise the findings of the prior research by Miron-Spektor et al. (2011) that people who use a paradoxical frame rather than another cognitive frame are more creative. Furthermore, this good relationship is assisted by a greater knowledge of conflict and greater complexity of integration, i.e. openness, open-mindedness, and adaptability.

managers refer to their cognitive models and the schemas that they developed in their professional experiences (De Jorge Moreno and Victoria, 2008) and previous expertise (Tang, 2008) to be deal with the newness and complexity of the new platform. Due to the uniqueness of HoloLens structure,

7.2.2. Top Chosen Factors by Participants

Overall, the top 5 nodes chosen in interviews were:

Factor	**Total**
Solving a customer problem	20
Design	17
Develop a strong team	16
Relationship with customers	16
Market Knowledge	15

Table 7.5: Top five factors mentioned by 31 participants

It is not a surprise that developers' most important factor was "Solving a customer problem". Previous empirical research has shown that between 10 to 40% of customers are involved up to a degree in developing or modifying new products (Lobaugh et al., 2019). It has been shown that innovative creators tend to have "lead users" characteristics. This can make the product commercially more attractive. Being customer-driven and trying to solve customers' issues can help developers increase their speed and effectiveness to test their products.

Solving a customer's problem has also been identified as one of the seven factors that maximise productivity. In research performed by Cooper and Edgett (1999), increasing productivity in new products, there are seven principles. The findings of this research add to Cooper and Edgett’s research. The first and most important one is to solve customers' problems and offer a compelling proposal. It should be noted that having excellent ideas is not an easy task, and it

requires an understanding of the customers and the market. This is illustrated in our findings too. During interviews, one repeated frequently was their effort to work closely with their potential customers.

"To make sure product is adopted by customer we all try to consider what are customer needs that we have to address in our project. If you are not answering any of their needs, customers won't be even interested to look at our application." —Participant 12

"From the beginning of development, we try to be in contact with our clients repeatedly to make sure we address all their needs and requirements in the application that we are developing." —Participant 30

It has been tried to make the customers are as a part of the entire product development. When considering the product's physical parts, it is the design that transforms the ideas and requirements into a more tangible item. Therefore, it can be considered as a border product development activity. Product design has started to receive more attention. This amount of attention highlights the belief in product management, which is essential to consider. Design can have a direct effect on the revenue too. This is understandable as the design is used to define features of the product, the quality of its performance and its reliability.

"I aim to attract as many as customers I can for the projects that I developed, and it is possible only if the design of my application matches what customers have in mind. the number of features that are used for the application impact its performance, so I have to consider how many features I want to add to make sure the performance doesn't drop."— Participant 20

In the early 1980s, marketing theory's main focus was understanding suppliers' perspectives (Ambrose et al., 2010). This is reflected in the large number of strategy theories developed during this period. Although some indications having long-term relationships with customers are mutually beneficial to both sides, customer relationships' importance was largely ignored. But recent works on this area have shown that this relationship should not be limited to fulfilling the companies need. An ideal scenario should satisfy customers' rational needs and minimise their reservation against building long-lasting relationships. This is an essential factor in ensuring the company's success for a long time.

The next important factor has a strong team. Good teamwork is required to make sure everyone work in parallels, co-operate and support each other. During interviews, something pointed out was that's strong team requires a diversity of thoughts. This can help increase the product's productivity and success and help the whole team learn new aspects of the job.

"*There it needs to be a strong team with similar vision and technical capability to get the development going for a project to succeed*" —Participant 7

"It is a very new platform…you can't know everything about it and its used software, so you need to form a team of knowledgeable and experienced developers to be able to develop a successful application. Without having the required knowledge, it is impossible to develop anything here" — Participant 12

The fifth most crucial node was market knowledge. The positive effect of market knowledge on the innovation of products and performance factors have been studied before. A company with a broader view of the current market, customers and competitors can make more successful decisions during product and design developments. It also can help in increasing the firm's speed to implement and execute complex tasks. An innovative product based on tremendous and in-depth market knowledge would make it difficult for competitors to observe and understand its functionality. This reflects that understanding the complex relationship between the customers' problems and potential competitors' strength will increase a highly unique and robust idea.

"My team needs to be ahead of the competition and the rivals that we have, not only in this platform but even in others. That's why we constantly track their applications improvements to see what features they have added. This way we know have they are trying to get customers attention and what problems often they try to tackle. We don't have many customers in this platform, that's why we need to come up with unique ideas for our projects to gain their attention." — Participant 4

Another point to examine when looking at these results is the in-degree and out-degree values.

- In-degree

The top factors with the highest number of Ids are shown in the table below:

Number	Factor	Id	Rank
32	Solving a customer problem	61	5
22	Relationship with customers	56	14.5
25	Develop a strong team	39	33.5
15	Design	35	15
1	Innovative ideas	32	8.5

Table 7.6: Top five factors with the highest Id

Solving a customer's problem has been identified as the factor with the highest number of ids. In addition, developers have identified market knowledge (12), relationships with customers (8), agility (6), personal leadership (6) and prototype (5) as the most important factors that influence their ability in solving a customer problem. In this list, numbers stated in brackets correspond to the sum of arches indicated between factors.

As can be seen, developers believe in solving s customer problem; they need to know what the current market is and why the current needs are. To be able to understand customers need having good relationships with them is essential. As mentioned earlier, customers can play a massive role in developing a new product. But timing is another crucial factor. Therefore it is not a surprise that agility was the third most important factor. A good product needs to meet customers need at the right times.

"I think the solving customer's problems are much more important to eliminate those that haven't support network. But I think the prize in agility and the iteration worried for your mistakes all play more important in the development of innovative idea you do have to have a support network, but you've got to have that iteration process in place first." — Participant 2

The other factor mentioned was a personal leadership style. This is an essential factor in making sure everyone in the team works towards the company's goal. It has also been mentioned that a good leader should provide an environment for the team to express their ideas comfortably. Such ideas can be essential in creating and improving the product.

"You know, when you work in a group, and each member of the group has their specialities, skills, and background, it is difficult to make everybody being the same page. That's why it's essential to have personal leadership style to make sure everybody in the group can speak about their opinions and ideas." — Participant 29

Finally, the prototype was identified as an influencing factor in testing and minimising the chance of failure for new products. This is another example where having good relationships with customers is an important factor.

"Since we're doing agile development, we're constantly creating small prototypes and small working concepts that we can show them [customers]. Then we should have something every week to show them, what's new and some sort of progress." — Participant 15

The second factor with the highest number of Ids was a relationship with customers. This is mainly influenced by solving a customer problem (18), developing a strong team (9), service quality (6), market knowledge (5), balancing the risk (3) and performance metrics (3). As explained earlier, solving a customer problem is strongly dependent on the relationship between the firm and the customers. To make this process smoother and achievable, having a strong team is very important. The following important factor that affects the relationship with customers was service quality. Increasing the service quality will have a positive impact on the relationship with customers. This requires a good understanding of markets and what is currently available to the customers. This can also help them to understand how they can be ahead of their competitors.

The other important node was balancing the risk. For any new product, it is essential to balance the risks. A successful team needs to be clear about uncertainties and associated risks. Currently, many teams do not see this as a priority, and consequently, they will be unable to balance the risks and lose many opportunities. Also, being transparent can increase the confidence of team members and customers in the product and show how ambitious the team is about this innovative product (Oehmen, and Seering, 2011).

Develop a strong team with 39 IDs was the third most selected option. Personal leadership style (6), support from the company (6), identify and obtain Human Resources (6), developing staff (5), market knowledge (3), customer innovation adoption (3), agility (3) have been identified as the factors that have the highest effect on the team. It is not a surprise that leadership style has the highest effect on the team. Recent researchers have shown that both team and leaders can directly affect each other (Zaccaro et al., 2001).

For a team to successfully work towards its goals, support from team members is not enough. The company needs to show its support too. This can be providing a relaxing environment where clients can focus and work or other equipment that the team needs to perform its tasks. Other factors include job security and regular awards. This is part of the company's Human Resources too. It should be noted that even forming the team is a part of Human Resource, which is why it impacts the team (Zwikael, and Unger-Aviram, 2010).

Another point raised during interviews was that the team needs to continually study the market to keep up with its needs and trends. But this requires educating the team members to have a good understanding of the current situations. It was also mentioned that allowing team members to learn and expand their skills constantly is essential to stay on top of the game.

"Although it is essential to create a group who knows the latest technologies, when you have a client who has a professional job and their needs are also linked to the daily job activities, it is important for the team members to have a good understanding of what are the clients' current needs what are the relevant trends that they can apply to answer those needs. in our team we have a specialist whose job is to track the current trends and we have a research team who would tell us what the most important needs are currently, at the end my team we tried to use our skills to address as many as these needs in the applications that we develop." — Participant 28

The next item in the table with the high number of IDs is the design. Again, the factors that have been identified with the most influences on it are innovative ideas (8), develop a strong team (8), continually develop product/services (8), personal leadership style (4), feedback from customers (2).

This was another point that was raised during interviews. According to participants, a good design starts with a fair and creative idea. That will then set the path for designers to work towards it. Something that was repeatedly mentioned was the importance of simplicity in the app while meeting client needs. However, this needs to be checked continuously, especially in the continually growing technology. Keeping good relationships allows developers to get feedback and constantly improve their app. Being on good terms with customers allows developers to get constant feedback and new ideas from their users.

The final factor with the highest number of indegrees was innovative ideas. Developers believe that this is mainly influenced by personal motivation (5), develop a strong team (5) personal leadership (4), continually developing product/service (3), existing customers (3) relationships with customers (3), performance metrics (3), learn from mistakes (3) and finally agility (3).

Innovation at workplaces has been widely investigated. Results obtained in these works have suggested that the most critical factor in obtaining new knowledge at work is knowledge sharing and reflecting the new knowledge in work (Shipilov and Gawer, 2019). This means having a strong team, and good leadership skills are the most influencing factors inside an organisation or teamwork. Our findings are in agreement with this idea too. Researchers have also pointed out that most companies miss many potential innovative opportunities by not taking into account potential knowledge that they can gain from customers. Managers need to understand what factors influence their products and how it stands in the market to understand how they can keep their innovative environment.

The leadership style of managers and the company's culture signal employees to bring their innovative ideas and supports them. A good leader will encourage employees not to hold back and support their ideas and any research work or learning activities that can positively impact the company. In research done on leaders, employees work in, and the company's national culture has been identified as the three most influencing contextual factors that affect the innovation (Lukeš, and Stephan, 2017).

To make sure the company is continuously moving forward, measuring the performance matrices is very important. This information can help managers know if they are doing enough suitable activities and learn from them, and fix the problems (Kylliäinen, 2018). To speed up innovation, companies need to be agile. To be successful in this field, companies need to focus on agility during regular times. The agility of a team can be measured by measuring the response time of the company. This depends on the time it takes to create a creative idea and pulse the production time. Then they try to improve it. (Rigby et al., 2020). This was another point raised during interviews:

"For us, the speed of production is another important point. We need to always meet a deadline. So, we try to break down the codes into small parts and divide them between different

developers. Then each part is tested separately to make sure the final code is robust. Handing an error free app to the clients is our number one goal." — Participant 22

- Out-degree

The next point that we examined was the out-degrees. Table below shows the t factors with the highest number of Ods.

Number	Factor	Od	Rank
25	develop a strong team	58	7
2	market knowledge	53	2
41	personal leadership style	50	49
32	solving a customer problem	47	16.5
22	relationships with customers	42	6

Table 7.7: Top five factors with highest OD

The findings of this section answer the main objective of this research: what factors complementors believe create success for their innovation. Having a high number of ODs means these factors can have great impacts. There seem to be many similarities between these factors and the top 5 IDs in the first look. However, it is interesting to note that the order of factors is different here. In this table, the top factor is the develop a strong team. Factors that it mostly influences are relationships with customers (9), design (8), service quality (6), continually develop product/ service (6), innovative idea (5), clear process (5), solving a customer problem (5) and learning from mistakes (5).

The relationship between some of these points was explained before. Here, I will look at the new relationships, like the effect of a team on service quality. It has been shown that if employees feel the excellent quality of the service within their team, they will reflect this on the product and the service (Windermere, 2018). Furthermore, researchers have shown that many companies have shifted their service quality check to a self-managed team effort; in such companies having a great team is essential to its survival (de Jong et al., 2001).

Productivity is another approach to examine production efficiency. This can mathematically be calculated by dividing the output by the input of the production process. A good team works closely towards its goal and reaches both the short- and long-term goals. An essential factor is continually reminding the team of the company's goals and bind it to each member activity to

keep them motivated. Although there is no fixed or definite approach to help a team's success, communication plays a significant role. Everyone in the team needs to have a cellar view of their team member strength and weakness. They can help each other overcome obstacles, which explains why having a good team is important in clarifying the process (Barnes, 2012).

Learning from mistakes is another point that has not been referenced yet. Traditionally mistakes were considered as a step-in direction of learning a new skill. But once a mistake is pointed out in a company, the team member may get offended and even try to repeat that to emphasise their point. To learn and overcome mistakes, good teamwork and a shared mental model is required. Recent researchers have shown that having a goal as a team and working towards it and problem solving encourage the team members to learn from their mistakes (Tjosvold et al., 2004).

The second point in this board was the market knowledge that is mostly influencing are solving a customer problem (12), analysis of product/service benefit (5), relationship with customers (5), planning ahead (5) and identifying distribution channels (4).

The importance of marketing knowledge has been explained earlier. To make informed and accurate decisions and evaluate the product, a good understanding of the market is essential. Based on information collected and the market's needs, a company's next move can be planned. Facts collected can help to be more objective when planning ahead (De Luca et al., 2007).

Such information can also help identify potential ways to make the product available to the customers. Overall distribution channels can be divided into two groups of direct and indirect. In the indirect approach, customers can buy the company's product/service an indirect method, the purchase is made through the platform or retail. It is essential to choose the right channel that aligns with the company's mission and needs. This requires a good understanding of the market (Wilkinson, 1996).

The third most influencing factor is personal leadership that affects the motivation of staff (6), learning from mistakes (6), solving a customer problem (6), developing a strong team (6) and agility (5).

Personal leadership is another vital factor in the success of a team. A good leader will know that teams do not need a member who listens and follows the leader's lead. They need motivated

staff that works toward the company's goal. Deming (1985) has introduced 14 points to transform western managerial styles. The first point in his system was the constancy of purpose. He believed that emphasising on the company's goal is the most critical factor. Therefore, they should learn from their mistakes, help each other and keep improving their work to reach their goals (Mastrangelo et al., 2004).

The next point in the table is solving customers problem. Results obtained have shown that the factors that it mostly influenced are relationship with customers (18), service quality (6), feedback from customers (6), analysis of product/service benefit (5) and developing a strong team (3).

During the interviews, something that was mentioned continuously was that the product needed to solve a customer problem. Therefore, having a good relationship with customers can help get feedback required to improve the service quality and better understand the service provided. But it is not just the customer's important feedback; to succeed, managers' feedback, team feedback and self-administered feedback are essential too (Bell and Luddington, 2006). Therefore, having a good team where everyone can express their opinions is essential.

The last factor in this table is the relationship with customers, which is mainly influencing solving a customer problem (8), identifying distribution channels (5), identify and recruit partner (3), feedback from customers (3), continually develop product/service (3), innovative idea (3), relationships with customers (3) and planning ahead (3).

Relationships with customers have already been discussed earlier. But there are new nodes that were pointed out here, which were raised during the interviews too. For example, Customers can help to identify distribution channels too. I have interviewed developers who started to work on an app after receiving the order from them. In this case, the app is personalised to solve the customer's issue. Such customers are the best distribution channels. They can introduce the product to other potential customers who are tackling the same issues. In some cases, they may be able to introduce other groups who are working in similar areas. This can then be useful to plan the future and expand the business too.

Summary

To sum up, this chapter focused on answering the research aim by analysing the findings of the interviews. The main aim of this research was to investigate complementors' information processing and decision-making during the development of innovation. Findings indicate factors that mainly influence the product result: customers, staff knowledge, and money. These answers also came up in indegree analyses focused on complementors objectives. Based on this finding, it can be said complementors form their objectives around the impact factors. As customers are the main drivers of innovation success, it is important to know how to solve their problems through building a relationship with them. In order to be able to answer the customer's needs, developing a strong team also is essential to consider. By having a strong team, complementors are able to improve their designs and find more innovative ideas.

This section also provided the answer to what set of beliefs complementors have about the platform in the process of developing their innovations. Findings indicate the most effective and important factor is linked to relationships with customers. It is opposed to the findings in prior studies, which indicate that complementors knowledge is the most critical factor for complements in a new platform (Bassellier et al., 2001; Teece et al. 1997; Thong, 1999). The main cause for this difference is the unique architecture of the HoloLens platform in which each app targets one customer or one company only. This difference has changed the mental models they created over their past experiences in other platforms.

Design and service quality are the second and third most important factors according to the participants, and they get linked to the complementors knowledge. This finding is in line with the entrepreneurial alertness theory, which explains basic knowledge of the activity, managerial abilities, and professional experiences of the managers have a direct impact on managers decision-making (De Jorge Moreno and Victoria, 2008). The innovative idea has been mentioned as the fourth most impactful factor. Since the HoloLens platform is relatively new and the number of app developers participating in it is low, the competition is not between applications but the app developers themselves. Therefore, having past working experience and networking plays a vital role for complementors in this platform. Through having a profound network effect, compliments do enhance their knowledge level and get direction for their decision-making (Khakbaz, 2012).

CHAPTER 8

ANTECEDENTS OF DEVELOPING INNOVATION IN AN OPEN PLATFORM

The literature on an open platform and complementary innovations highlight what antecedents affect the platform's strategic management and success. However, these kinds of literature lack focus on strategies developed at the business level when developers join a platform and aim to produce complementary products. To better understand what factors influence their decision-making and strategy development, it is critical to know their development context. Therefore, this study's findings have focused on the antecedents of developing and launching complementary innovations in the HoloLens platform.

8.1.Recourse

To positively affect the platform's ecosystem, the priority of the platform owner should first move to create apps for offering services to help complementors in their project implementation. These services are known as platform boundary resources (Ghazawneh and Henfridsson, 2013). It includes software applications and legislation that act as an interface for a long-term partnership between the platform owner and the program's creator. These are imperatives to *"transfer design capability to users"* (von Hippel and Katz, 2002, p. 824) since they, in essence, are meant to make additional innovation development in the context of an application. Technology cost analysis also is among the essential activities for handling software programs. Expenditures in handling a project directly linked to the growth of an application's size and complexity. Also, accurate budget measurements are particularly desirable throughout the preliminary development phases (Xu and Khoshgoftaar, 2004). A big challenge in the cost analysis of applications is first to achieve an accurate measurement of the value of the data to be created (Kitchenhamet al., 2003).

8.1.1. Finance

This research's findings illustrate having access to financial resources plays a crucial role in developing complementary innovation. Participants do have a strong belief in the impact of

generating and managing finance on their innovation success. Leading factors affecting the price of the application are the type and location of the suppliers, number of features of the project, backend structure and attached application programming interfaces (API), difficulty of user experience and user interface designs, presence of extra exclusive visual features, development tactics used, and the number of platforms it is going to be developed. The quotations from participants 3 and 15 state their experiences developing an application for the HoloLens device and how much money and time are correlated in project efficiency.

"The project we work on is in between agency work, so the amount of time we have available is certainly a strong influencer on how much we can get done for the product. There's also money as an influencing factor of course, which is if we have enough money left over from agency projects to dedicate hours to our project." — Participant 3

"The amount of money that the companies are interested in providing for the product so whether that limit everything from the team size to the amount of time we can spend on it and it limits the scope of the entire project really. Also, time allocated for development matters […] it gets related to the cost which is how long they're (the money) coming when the company wants to see results and how long the company can continue paying for development […] it's all quite innovative and unproven, companies want to see results before continuing investment. Because they're not sure if there really will be any results […] because it's all quite new." — Participant 15

Planning and leadership style is essential for countering the reaching spread, controlling construction costs, and maintaining the anticipated return on investment (ROI). There have been three significant domains to handle, from early conceptualisation to eventual launches of the project. Maintaining such aspects allows complementors greater leverage throughout the cost of their development. These three domains link software specifications and usability to potential customer issues while designing and testing, ensuring that such features are designed with no mistake during production and redirect the unavoidable adjustments in production into the original work target's achievement. Developers who faithfully manage all three growth domains are vital to satisfy customer demands and sustain loyalty throughout time. This method allows maintaining production expenses when focusing on the project's ultimate commercial intent compared to product management.

8.1.2. Technology

Besides how apps should function and what services are needed, defining the kind of technologies that would better support clients' demands is necessary. The importance of understanding the usability of technologies has been investigated from two different angles. Accessibility to the software programs used for Microsoft, the HoloLens headset, and Android and Windows Store. Holographic Applications require software programmed to take control of Windows Holographic application programming interfaces. The Unity Framework is preferred for designing 3D applications. To guarantee customer satisfaction, considering the application's adaptability and its new technical features plays an important role. Features being used in the application must be continuously checked with the customers to prevent product adoption confusion.

"Customers [...] they're the ones who are going to decide how they're going to adopt it what they're gonna use it for? That's if we don't make something the customers' want, then we're not going to be making anything for real." — Participant 7

Due to the high cost of the device and the project to be developed, customers expect to receive a product with high-quality features and technical excellence. Any miss calculation or error can lead to project failure and miss the opportunity to be launched into the market on time.

"The technical excellence is that we have to create the application well and support it well and make sure that it's functioning in the best way possible. So those the other two factors [customers adoption and the right time to market] can be supported. If you have an application that doesn't work well, it's not going to reach mass adoption. It might get you to the market faster but the whole point of getting to the market faster is to have something that's adopted quickly." — Participant 26

"When doing a project, for potential client the first step is to put this whole last device on, and the customer has never tried that technology before and there's generally no understanding about how this technology works at all or what are its limitations and finding out viable use cases is kind of difficult from that starting point." — Participant 7

The launch of appropriate strategies for technology management involves a variety of factors to be placed in motion. Firstly, functional resources are required to help managerial decisions

and actions and strategies for their use. Furthermore, management systems are needed to combine tools and strategies to solve specific business challenges. Lastly, philosophical structures are required to direct the perspective on technology governance drawn on well-founded theoretical concepts. It is crucial that the resources, procedures and mechanisms that are set in place to support the innovation process would attempt to be stable (practical and efficient), financial and realistic to execute (not very complicated or resource advanced) and adaptable.

8.2.Customers

Prior research in open platforms emphasises the importance of customer satisfaction and its link to success for the platform and its complementors (Helfat and Winter, 2011; Helfat and Raubitschek, 2000). HoloLens follows a differentiation strategy by only targeting users with professional jobs such as surgeons and engineers. Recently, developers have developed applications used at hospitals today to monitor and treat Covid-19 patients. According to imperial.nhs.uk (2020), through this device's use, Imperial College Healthcare doctors have minimised physical contact with sick people up to 83%. In addition, the application developed helped doctors "*share medical notes, scans, and x-rays via the headset*" (imperial.nhs.uk, 2020).

Although the number of users is rising, this platform has a limited number of customers who would use it. Excluding non-professionals as the target audience resulted in specific opportunities and difficulties for the platform. On the positive side, the percentage of rivalry is low as the number of applications being developed for the platform is low. Each app is targeted to a specific customer and cannot be sold or used by others. It makes competition difficult as applications being developed for one customer or one organisation only. However, for complementors, having access to customers plays a critical role in the survival of their complementary innovations. Not having many potential customers to target can discourage the complementors from staying and developing innovation continuously.

8.2.1. Direct Approach

The direct approach refers to developers' ability to find and have close contact with customers from the beginning of the project development. In this scenario, developers are either being

approached by their customers looking for a professional developer with the right skills to develop a mixed reality application or know the customer due to some circumstances.

A few developers who have been interviewed in this study stated that their applications are linked to their previous working experiences. For example, their customers are their former colleagues from the workplace or the environment they used to work.

"For 14 years, I used to work as a constructional engineer. Three years ago, I got interested in mixed reality and augmented reality products in a way that I decided to learn to program. I formed a group of skilled developers to produce a number of applications that would help construction engineers with the jobs and minimise the number of errors they might face while working on their projects. After finishing the prototype with my team, I decided to show it to some of my friends I know from the past, resulting in getting official orders from a few of them. Now, I have experience of developing three successful applications for my customers using mixed and augmented reality devices." — Participant 28

In general, having past working experience in creating software applications on different platforms played a huge part in attracting and reaching customers directly. The majority of the participants in this study joined the HoloLens platform after having several experiences in developing software applications on other platforms. Either they approached their previous customers to develop a new application using HoloLens mixed reality software, or because of the requests they got from their customers, they joined this platform. In some cases, like participant 12, having a background in developing applications for other platforms could get a job offer from customers.

"I once developed a VR app for a surgeon to use in one of his classes. His satisfaction resulted in him asking me to develop a similar application for him using HoloLens device." — Participant 28

"In the company I work, we are all software developers. Clients contact our company and mention what kind of application they want and for what sector. Based on the criteria they mentioned, team advisors will recommend us to them and ask us to develop the project they have in mind." — Participant 12

Overall, the developers' past working experience, knowledge, and skills are the players in having access to customers directly. It also results in the ability to develop a successful project on a HoloLens platform.

8.2.2. Indirect Approach

The indirect approach refers to when developers try to find customers for their product after reaching the prototype stage. Developers who take this approach have a lower level of working experience. According to participant 3, attending exhibitions and seminars plays a crucial role in finding customers. As developers need to alter their app development features based on each customer's needs and expectations, it is challenging to approach potential customers online and advertise. Consequently, face to face meetings has been the critical element to reaching users.

"Attending exhibitions and events help us to meet our target audience and potential buyers face to face. We let attendees to try our prototypes… this way we get their attentions about what we can offer, our talents… and through the discussions we have with them, we might be able to pursue them to work on a project with us and we develop an application for them." — Participant 3

Having contracts with dealerships that would find potential customers is another way that complementors try to approach customers. They do not go after the customers but the dealerships; they take the app to the shows and present it to the potential customers. It is because of the low number of potential customers that would decide to buy the product.

"The fact that matters with HoloLens… aren't the customers say "I'm ganna buy one". That's just not the target audience that we're going after… We started somewhat of a rental program where we rented a HoloLens to show to the dealership if they want to take it to like a show or a trade show or whatever, but we also are usually just have representatives from premier to take the device to the show and then they're the ones who operate into the show so that's our distribution model, I would say." — Participant 31

8.3. Human Factors

There are three critical human factors mentioned by participants which are essential to consider when developing the product. Knowledge, contact, and experience are the essential elements, according to developers in this study.

8.3.1. Knowledge

Innovative architectural methods become highly knowledge-oriented and interactive. Knowledge-intensive assistance is becoming increasingly important in the design process and is an integral approach for software development's potential strategic benefits. Therefore, complementors' knowledge about the software systems being used by HoloLens plays a crucial role in developing a successful innovation. Some developers require having a team to be able to develop the application for their customers. Therefore, having a strong team plays an essential role for the application to be successful. To enhance the quality of the complementary product for the innovative production process, it is essential to supply knowledge aid and exchange development knowledge between the team members as it is mentioned by participants 7, 12, and 23.

"*There it needs to be a strong team with similar vision and technical capability to get the development going in order for a project to succeed*" — Participant 7

"It is a very new platform…you can't know everything about the it and its used software, so you need to form a team of knowledgeable and experienced developers to be able to develop a successful application. Without having the required knowledge, it is impossible to develop anything here" — Participant 12

"Knowledge is all you need to make a functional innovation […] The interaction that we have in the team meetings is the source of knowledge building." — Participant 23

Knowledge about the software and hardware parts of HoloLens allows developers to adopt the required knowledge to develop their application in a shorter time and faceless technical error during the development process. Factors impacting the accuracy of knowledge in the HoloLens platform are having highly skilled and the right members, the complexity of the platform features, rules, and regulations, and getting proper feedback from customers.

8.3.2. Contact

Having direct contact with customers allows developers to minimise the potential errors and faults in the application from an early on. One of the key strategies used by developers is to build a prototype and show it to customers to try it before the final development. The prototype also has a direct positive link with application design. Developers can enhance and make new changes in their innovation-decision according to the customer's expectation and monitor their satisfaction by showing the improved version of the prototype on a weekly basis.

"Since we're doing agile development, we're constantly creating small prototypes and small working concepts that we can show them [customers]. Then we should have something every week to show them, what's new and some sort of progress." — Participant 15

"The prototyping and the evaluating the prototypes are a key step in the process of your following and it is just not a step it's a process and basically, we're going to do a lot of prototypes as to see how satisfied they [customers] are with it and trick to design that way." — Participant 23

Participants 10 found it useful to give his prototype to university students in the same field of the project topic, with insights about the prototype being developed. It lowered the chance of having misunderstandings and confusion in the production process. It also minimised the time and expense spent. In addition, prototyping increased the accuracy of getting the client's expectations and requirements. Students were also able to share some critical ideas and suggestions from their perspective, which improved the design and functionality of the prototype.

"The MVP I created, I tried to demonstrate it to college students […] you know, they are young and can give very critical feedbacks about the functionality of it. It helped us to save time and money. You know, prototypes cost money and to make a new one you need to have funds. Having other peoples to try the prototype apart from your customers help getting closer to the ideal design." — Participant 10

These findings show that keeping contact with both internal and external parties allows complementors to understand the need for creating a solid innovation.

8.3.3. Experience

There have been two main reasons for developers for joining a new platform like HoloLens: gain new experiences or use past experiences to develop. The developers' past working experience in building applications plays a crucial role in adopting the new software program used for the HoloLens device. In addition, the past knowledge developers might have increased the chance of creating a successful innovation.

"What differentiates us from other start-ups, it is that you know we've been in the industry; we've been developing mixed reality applications for a long time as far as mixed realities been around anyways and so we just have more experience in creating these good experiences in mixed reality and knowing how to think spatially and not obey a TD application that's floating in space. I mean our advantages are flexibility and great experience." — Participant 31

For other developers like participant 13, the ultimate purpose of joining the HoloLens platform and developing an app is to build a new experience.

"I'm a true believer that mix reality is going to be the future of reality. I think it's gonna be how people interact with the world and I want it to be on the leading edge of that. And be a part of that, and that was my primary motivation. So, it's a passion." — Participant 13

This being compared to prior findgs of xxx

Summary

Overall, organisations' ability to manage uncertainties and complexities in developing complementary innovation depends on which antecedents they have. This study's findings illustrate several antecedents that play an essential role in developing a successful application in the HoloLens platform. These antecedents are divided into three significant categories resources, customers, and human factors.

Resource plays as a critical element for creating and implementing innovations in a new platform. Having access to financial resources enables developers to create a much more substantial project. Depending on the location and the type of the application being developed,

what kind of APS is being used, what visual features are being added, and how many platforms this app will be used in, the amount the developer must pay for creating the project might differ.

Developers are able to reach customers either directly or indirectly. In the direct approach, customers attempt to contact developers to create an application that would address their real needs, or developers knew their customers because of their past working experiences. Therefore, they could easily convince them to develop further projects for them. On the other hand, the indirect approach mainly focuses on developers attempting to find customers. It includes finding customers or attending seminars, conferences, or even events to meet and find potential customers directly.

The final antecedent was human factors. The developers' knowledge level can speed up the work process and improve productivity than developing an application. In addition, having close contact with customers allows developers to reduce possible errors and address customers' needs more efficiently. Finally, past working experiences of developers can also help them understand the platform structures, software being used, and the process of developing a holographic application in the HoloLens platform.

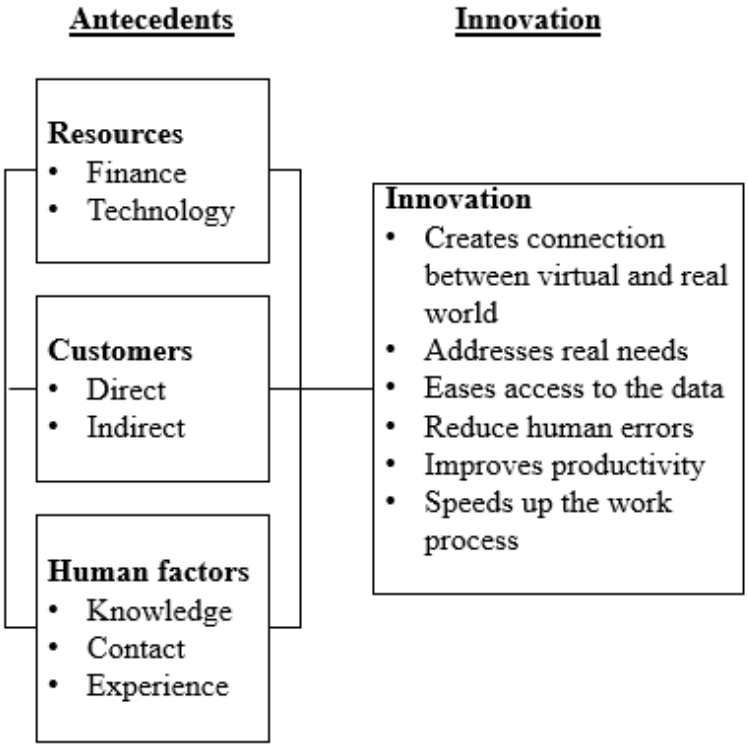

Figure 8.1: Antecedents of developing innovation in an open platform

CHAPTER 9

CONSEQUENCES OF DEVELOPING INNOVATION IN AN OPEN PLATFORM

This chapter focuses on what participants believe to be the consequences of developing complementary innovation in the HoloLens platform. These findings have given a detailed understanding of what developers achieved from developing a successful innovation. According to developers, to reach these consequences, several modifiers shaped the outcome of their work. The following sections give precise details about these elements.

9.1.Gaining Knowledge

A successful development of innovation involves an active and productive connection between knowledge and operational processes. Throughout development, complementors have incorporated prior expertise and adopt new practices to produce a practical application within budget limits and in a given time. It has been done through learning and improving their knowledge about the structure and expectations of the platform. Integrating knowledge about the platform's structure, ecosystem, and networks have helped developers get a clearer picture of how marketplaces build, catch value, and interact with others (McIntyre et al., 2020). New gathered knowledge added to the requisite application development and regeneration, whereas prior knowledge implementation resulted in higher quality or value production. Thus, knowledge development and implementation have been two main facets of creativity and innovation. In addition, the learning process and knowledge development have influenced internal and external factors, such as the feedback developers received from customers, technicians, or other developers.

Prior knowledge supports developers with an enhanced opportunity to "see" rather quickly essential links between ideas (Busenitz and Barney, 1997; Logan, 1990), which improves their capabilities to find further job options. Prior knowledge also allows individuals to have an enhanced imaginative capacity to create more inventive possibilities (Cohen and Levinthal, 1990). According to developers, developing a successful application has expanded their

knowledge about customers, staff, and market needs, resulting in building more appropriate skills for their future opportunities.

9.1.1. Customers

One of the critical consequences of developing a successful application for complementors is having a satisfied customer. Building a positive and robust relationship with customers allows developers to improve several aspects of their development performance. Through continued communication with the customers, complementors have been able to improve their "Service quality". Participants 1 and 15 revealed their weekly meetings. The prototype trials helped them get a more in-depth insight into their customers' demanded services and their level of understanding about the services being added to the application. As a result, these meetings let in providing a satisfying application with high service quality. Producing high-quality services is the key to reaching a viable competitive advantage which is only possible by understanding customers' needs and expectations (Shemwell et al., 1998). The knowledge and experience that developers have gained from developing a successful project have provided the opportunity to meet more customers with similar expectations. This has also helped developers with solving their problems too.

According to participants 21 and 19, "Solve a customer problem" has been a positive customer interaction outcome. Through having close contact with customers and asking their opinion about the prototypes created weekly, developers have lowered the probability of making mistakes or facing errors. It has also improved the application design, which is another factor that has been mentioned by participant 19. The following quotations support these points.

"*We held weekly meetings in our office with our customers to show them our updated prototype. [It was] very time consuming but it worth in at the end. We helped our customer see the application process every week, and they told us how they felt about it. We fixed any bugs or problems they mentioned during the week and showed the new prototype the week after. In the end, we made the exact application they wanted. To me, it means success*." — Participant 21

"*There is a positive relationship between solving a customer problem and design. The more I could get my client's opinion about the application [in the process of development], the better the design became at the end. It's as simple as that."* — Participant 19

Participants 12 and 15 mentioned knowledge about the customer help with facing a lower level of competition. Since applications being developed for customers are personalised, the probability of facing competition is very low. As a result of the work's personalisation, each developer has taken an entirely different approach to developing their innovation.

"Tekla is a bit bigger than Insanelab. But, they were all relatively small, I believe they've all got different kind of approaches towards the same market. Tecla is looking at distant manner factoring industry and how to help frontline workers, Black Marble is very local to us where we currently are, so there's that sort of competition, and insanelab is attempting to redo things like a mixture of the accelerators and kind of use some of the fame that was created during the mixed reality accelerators for their own purposes… so each of them in different ways is trying to have the same kind of sectors as we are in different ways. " — Participant 15

"So, I would define it [competition] as the knowledge or it may be even expertise that my competitors have…so if there's more knowledgeable competitors… well it could influence the relationship with the customers. You look at it from the point that you didn't try to differentiate yourself from your competitors from the size of the organisation; you try to compare from the last point that you are… because you're a startup and you have your company, so you are more flexible compared to your competitors [in terms of your device and how do you think]. That's what differentiates your product. You're in about your app, that's what differentiate you from the others." — Participant 12

Overall, there have been several outcomes related to customer knowledge. However, the "relationship with customers" has been the most critical factor. The outcome of the in-degree analysis in chapter seven also illustrated in all three groups; relationship with the customer has been mentioned as one of the top five factors. Since the applications are very specialised and they are developed specifically for a single customer or organisation. Therefore, complementors believe that having a close relationship with customers can help with balancing risk, which leads to the ability to solve a customer problem. Eventually, these can improve the design and the service quality.

Consequently, having a successful product will improve and increase the relationship with customers. This can be essential in future projects too. Figure 9.1 below shows this relation.

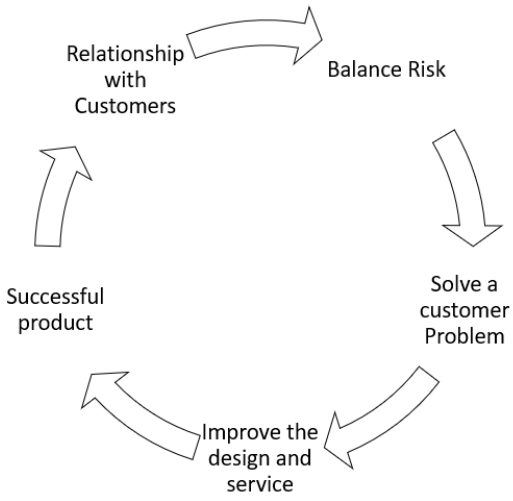

Figure 9.1

9.1.2. Staff

Multiple factors have an impact on staff knowledge. By exercising their daily operational and developmental roles, developers build several specific principles for information exchanging, retaining, and reinforcing values (Tohidinia and Mosakhani, 2010; Zboralski, 2009). Although personal and operational factors are significant to consider, technical factors need to be considered too. In this regard, Geiger and Schreyogg (2012) mentioned promoting and enabling knowledge sharing is primarily driven by the support networks that developers receive. Through constant communication with other team members, developers have improved their experience and skills about the device and its software. As a result, they tend to be more creative and develop an application with better design.

"When you develop a strong team, your product design would be better because you would have more competent people experts in your team who can understand customers' needs and solve their problems." — Participant 21

"Recruiting strong partners has a strong relationship with your product design… everybody suggests ideas based on their experiences and you get to choose the ones that you know help with the functionality of the application. More detailed and professional design positively impact on differentiation of your product and services as well" — Participant 23

Interaction with technicians and project researchers also helps developers improve their knowledge about the application and the project subject that it is related to. Although it is costly for them to get help from an expert, they need to get external help for their project success.

"When you plan to develop a new product, you need to have a proper understanding of the project subject. I am developing an app for a heart surgeon, so I had to learn about heart function and structure before starting the project […] keeping my relationship with the client is the only way to make this app […] It is a life-saving project, and I can't afford to make even a tiny bit of mistake." — Participant 12

Support from the company developers facilitated them with knowledge sharing and the ability to use the latest tools and resources to create their innovation and higher productivity. Sohail and Daud (2009) suggest that information technologies can offer comprehensive and essential knowledge-sharing tools by eliminating time and space limitations among members, including teleconferencing, digital networks, Slack, Twitter, and Facebook (Suppiah and Sandhu, 2011). Moreover, elements like usability, accessibility, and the ability to position knowledge accurately also impact the developer's ability to develop a thriving innovation. Participant 5 emphasised this issue.

"Each time I have a technical issue, I contact the company I work for because they are very helpful and active […] they have provided all the facilities I would need to be able to keep in touch with them. They also suggest solutions and resources to use to fix the problem. This level of support has a positive impact on the performance matrix." — Participant 5

Knowledge sharing is a necessary element in optimising performance (Kumar and Rose, 2012). Knowledge sharing benefits from the formation of new knowledge and new technologies that lead to improved developmental performance. Having an experienced and knowledgeable staff member puts a positive impact on "developing a strong team", "solving a customer problem", "performance matrix", and "design" of the application. "Relationship with customers" is as effective as "support from company" in enabling staff members to gain the required knowledge to develop successful innovation in the HoloLens platform. Therefore, improving staff skills and knowledge level has been named one of the important outcomes of developing an app.

9.1.3. Market Needs

Due to facing a fast-changing market, having a complete understanding of the market's current needs and issues can be critical for developers. While disruptive innovation realigns the demanding market and produces novel business possibilities, several strategies have been introduced to describe its generators. The knowledge-based perspective

has received increasing popularity. New software creativity is mainly a feature of its capacity to control, retain and develop expertise. Developers with extensive knowledge domains have been able to produce cutting-edge concepts and advanced variations of knowledge elements. Comprehensive knowledge and experience with diverse, cumulative insights and suggestions enable the awareness of new information and future developments. In addition, it improves the complementor's capacity to identify external technical or business trends. To get up to date knowledge about today's trends, participants in this study emphasised two techniques. According to participants 8 and 26, the most popular way to understand market needs is to attend exhibitions and events held by Microsoft HoloLens and MR developers.

"*We go to local events like science centres that are what my career is based on. We go and look at those kinds of things. We go to a lot of community outreach from the education perspective because we see the lack of focus on this kind of technology and we feel like there's a lot of potential with AR and XR development especially from there, as there are a lot of different aspects to it. There's the arts side of it, there's the development side, there's the distribution side, there's the human factor side […] "* — Participant 8

"Exhibitions and events inside the industry were mainly offline. We attended many of these events to get clear ideas about the market, competition, and potential customer's characteristics." — Participant 26

Another way of gathering knowledge about the market needs has been through the community page HoloLens developers have created on Slack. Using Slack, developers discuss their concern about the lack of access to supporting software related to their work. This interaction has encouraged developers to form a team with others to develop the required software for other developers. Based on cognitive maps participants drew, there were many factors that market knowledge had a positive impact. But the ones that received the highest positive impact were "differentiation of the product/services from competitors", "solving a customer problem",

"analysis of product", and "Planning ahead". Findings illustrate participants believe that when they have a higher level of knowledge about the needs of the market, they can develop a more specialised application that would meet the customer's expectations and solve their problems. Consequently, this makes it harder for rivals to bring a similar product into the market. Moreover, with more critical knowledge, developers can predict and plan for possible issues in the industry.

"I suppose understanding customers' needs in the market is extremely important. You want to develop an application your customers would want to have it more than your rivals… that's only possible when you address as many as their requirements."— Participant 25

The higher a developer's knowledge is about the market he is working in, the greater his chance of developing specialised applications. Creating more unique applications can prevent potential competitors from taking over the market. However, market knowledge can also be perceived as a negative factor as it can lower the chance of creating a "Barrier to entry". According to participant 8, a higher level of market knowledge can make it easier for competitors to develop similar products as developers.

"There are only a few customers currently related to the area we work […] If other developers try to join in and start taking similar project as us in this field, there would be a higher chance we would lose customers to them, and it would be difficult for us to stay in the same field with a hope we could get more projects." — Participant 8

Consequently, developers believe market knowledge is one of the most influential factors impacting the product result. To produce a complementary innovation in the HoloLens platform, developers need to understand market knowledge. Factors impacting developers' market knowledge are a support network, a strong team, and personal motivation.

9.2.Financial Reward

The reward system has allowed businesses to develop, identify, maintain, inspire, and produce high-performance complementaries. However, it also impacted their performance on project development and management (Yousaf et al., 2014). Developers expect financial rewards for what they develop and the services and activities they offer. Pay and bonus are part of the financial rewards that developers expect to receive as part of their projects.

9.2.1. Salary

Salary/Pay is the payment of staff which is adequate to their abilities, experience and goals. Money is highly valuable as it helps developers to satisfy their fundamental needs. Pay schemes, which developers believe to be reasonable and equitable to their abilities and desires, are called pay or salary. Complementors receive a financial reward for the services they develop and offer, known as pay, and it is a prime rule in human resources management. Salary is always tightly related to the success of high performers. Staff who were able to develop a functional application on time could receive an adequate income that met their expectations. Pay equity helped them feel respected enough that they expected to be paid for their contributions.

"The amount of money that the companies are interested in providing for the product so whether that limit everything from the team size to the amount of time we can spend on it and it limits the scope of the entire project really."— Participant 15.

Their indivisible commitment to the project has distinguished complementors with a higher level of prior knowledge from others. These participants believed they managed their task and concentrated their efforts on the project. Experts (who were more knowledgeable) were more likely to evaluate a job in-depth if they provide details about their information. This indicates that people with greater experience will get involved with a project at a stage where financial rewards no more are the reason to develop.

9.2.2. Bonus

Some developers had received bonuses when they provided more than the requirements and goals they promised. Then, based on how satisfied customers were with the application developed for them and its usability, they gave developers further bonuses. According to 24 and 30, receiving bonuses increased their job satisfaction and helped them feel more motivated when developing their complementary innovations.

"the bonuses we received gave us more reason to develop applications having better design and features." — Participant 24

"I think, motivating staff to stick to key values is critical by giving them rewards or bonuses to promote the engagement process and their devotion to projects." — Participant 30

The number of payments is related to the level of success through an opportunity dependent bonus. Developers were expected to aim for a high-quality application with all the required features within a given time, ensuring their performance would be powerful during the development period. Consequently, factors such as timing of product/service, service quality, and design play are linked to the probability of receiving bonuses from clients.

9.3.Gaining Popularity Among Developers

9.3.1. Partnership

Popularity among developers is possible when developers have successful experiences in developing complementary innovations for the platform. According to participants 15, 19, 27, and 31, social media platforms helped them create a strong profile image and promote themself. Also, active participation in community group pages such as LinkedIn and Slack to answer other participants' questions and share opinions creates a more robust image for the developers.

"I found LinkedIn quite useful in building connections with other developers. Like I added all my past experiences on it and joined group pages created by others there. And well I found this way I was able to interact with others and show my presence too" — Participant 31

"On Slack, everybody shares any news they find, their opinions, issues… their findings related to the [HoloLens] device or the software programs. So, I found my participation in discussions helped me to get to know other members." — Participant 15

Developing a successful application provides several advantages for developers. First, the connections between complementors can positively lead to a partnership with them. Second, having a successful experience in the HoloLens platform does help with getting recruited in new projects. Finally, according to participant 15, identifying and recruiting strong partners increases the chances of producing a functional application in a shorter time and with fewer technical errors.

"If you have a strong team and good communication with them, you can foster their skills to develop the project. Having a strong member helps with your team project: they are more enthusiastic about developing and trying the prototypes, and they usually make less mistake on the way." — Participant 15

9.4.Increasing Customer Base

Due to the structure of the platform and the fact that it is only targeting specialists and professionals, participant 27 was able to get new projects because their customers recommended other potential customers to them. It is only possible through satisfying customers.

"It is not easy for us to find clients on this platform, [so] the best strategy is to get a recommendation from our previous satisfied customers… we kept improving the app design based on problems customer had at the prototype stage and minimised the possible risks they could see after launching it. All of that ensued in producing a functional application that customers were happy with. Their happiness provides us with more job opportunities." — Participant 27

A good reputation also helped developers to receive job opportunities from a similar type of customers. For example, participant 11 developed an application for university students majoring in Astrophysics. This application's impact on student's grades and understanding of their course helped him get other job offers from other lecturers or other departments in the same university.

"The application I made was used by university students. It was for an AR device. Students could see the universe and planets with some information and facts about each of them… this app became very well received. This got me more job offers from other professors at the university. Developing a mixed reality app was suggested by another professor. That is how I started working with HoloLens device." — Participant 11

The above scenarios indicate that compliments need to have successful experiences in developing applications to succeed in this platform. Supporting factors such as "solving a customer problem", improving "design", "balancing risk", from building a strong "relationship with the customer" and having constant interaction with them allowed developers to raise the chance of their application success in HoloLens platform.

9.5.Job satisfaction

Job satisfaction is essential for developers to continue developing complementary innovations for the platform. Job satisfaction involves the personal judgment of developers towards

fundamentally relevant problems. Since these evaluations include emotions and thoughts, workers may face significant effects on their private, social, and professional lives and affect their workplace behaviour (Sempane et al., 2002). Job satisfaction could impact employees' motivation, work engagement, and even confidence. This study's findings mentioned motivation and professional confidence due to developing successful innovation in the HoloLens platform.

9.5.1. Motivation

Many factors play critical roles for developers to feel motivated in producing complementary innovation for a platform. HoloLens allows developers to launch their apps on multiple platforms. This action encourages both existing developers and potential developers to develop applications continuously for the platform. Moreover, job satisfaction, job security, freedom of working for more than one platform simultaneously, and launching their developed application in multi-platforms are the factors linked to the policies and governance rules of the HoloLens platform. Performance and efficiency increase the motivation of the employees. Motivated developers are more independent and self-driven than employees with less motivation.

In comparison, enthusiastic workers are quite interested and eager to work on their roles and practice (Kuvaas and Dysvik, 2009). Participants' salary, constructive communication, and information sharing have been stated by participants as elements impacting the developer's motivation level. Complementors with higher motivations are more expected to have more opportunities and are not afraid to take more innovative projects.

9.5.2. Confidence

Professional confidence is counted as one of the highly desired characteristics of effective production (Hecimovich and Volet, 2011). Developers' confidence level in the HoloLens platform has been linked to how much they have finished a project and produced a successful application. In addition, past working experiences, the complexity of the project, and customer satisfaction play an essential part in increasing developers' confidence in the platform.

"*I have more confidence now to get involved in more projects and work with others."* — Participant 14

"The more projects you accept and finish, you get more confidence to deal with more complicated projects." — Participant 31

Job satisfaction affects improving the confidence of the developers. The HoloLens platform also offers complimentary training to improve its complementors' professional capabilities. In addition, HoloLens provides further training, tutorials, and lessons linked to using the device and Unity software to assist complementors in designing high-quality apps and encourage them to accept other job roles in the platform (Microsoft, 2020).

Summary

Overall, developing a profitable innovation does have several positive outcomes for complementors. By gaining knowledge about customers, developers have built stronger relationships with them, solve their problems, and make it harder for competitors to join. By developing prototypes and having constant interaction with clients, developers have increased their innovation success.

Staff knowledge is also mentioned as a positive outcome of developing innovation in the HoloLens platform. In general, knowledge sharing has been stated as the most influential factor in the success of innovation. Through sharing knowledge, developers communicated their understanding of the critical issues they face in the development stage with other staff members. Staff decisions impact developing a strong team, solving customer problems, performance, and design. In return, staff knowledge about the platform and its complementary development system tends to be impacted by factors such as support from the company and close relationship with customers.

Developers believe having an adequate level of knowledge about market needs helps with their developments in this platform. Several factors impact market knowledge, such as developing a strong team, having a support network, and having a high level of personal motivation. In return, their knowledge tends to get impacted based on how strong their team is, how much they can solve a customer problem, and how much they can differentiate their product from competitors.

The financial reward had a direct influence on developers' motivation and decision-making. Developers expect to receive a financial reward for the works they put into the projects they

develop. Salary or pay is what developers receive for their abilities and skills from their prior experiences. Time and quality of the work do have an impact on the salary rate. Developers with more knowledge and experience joined the platform to get the market knowledge and look at it as an experience. The findings of this study illustrated some developers were also able to receive bonuses for the tasks they were involved with. Participants admitted to working harder and developing a higher-quality application within a given time when they knew they could receive bonuses. Therefore, factors like the timing of the product/services, service quality, and the project's design could have played a vital role in getting bonuses.

Participants stated that they could gain popularity among all the developers depending on their complementary innovations for the HoloLens platform. In addition, social media platforms such as Slack and LinkedIn provided this opportunity for developers to promote Themselves and show their knowledge/skills about the platform and the software being used in it through the conversations they could have in the company community pages. As a result of this, they have been able to get invited to new projects.

Due to the newness of the platform and its unique structure, which targets specialists, many developers are struggling to find customers. Creating a successful application for HoloLens developers has allowed more job offers from other customers in the same industry. There is also the possibility that satisfied customers would recommend other potential customers to the developers. Developers can solve a customer problem, develop a functional application with appropriate design and balance any possible risk that might happen when they are developing the application to help developers increase their chance of producing successful projects on the platform.

Job satisfaction plays a strong motive for developers to stay and develop further projects for the platform. Emotion and judgement of developers are two fundamental elements of evaluating job satisfaction. The higher the satisfaction rate, the higher the developers' motivation and confidence in developing innovation for the platform. Job satisfaction and security and the freedom they would give to the developers are essential to increase the motivation and confidence of the complementors. Salary, ability to communicate and share information with other developers and customers also can elevate the developer's motivation level. Complementors with more confidence have a better chance of staying on the platform and continue developing further projects.

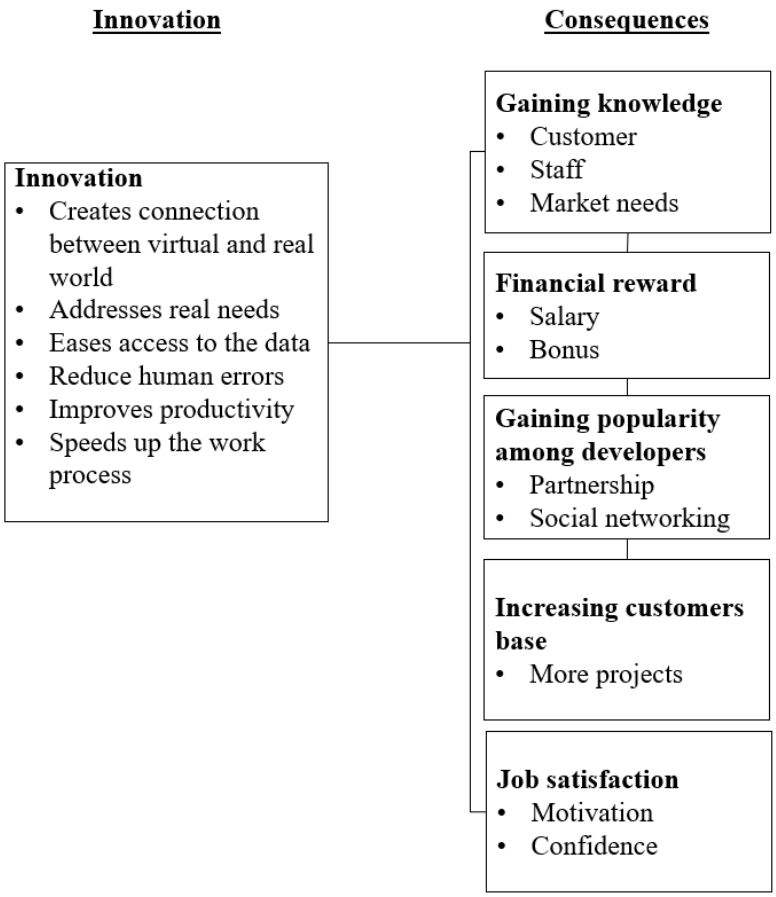

Figure 9.1: Consequences of developing innovation in the HoloLens platform

CHAPTER 10

MODERATING FACTORS AND THEIR IMPACT ON INNOVATION DEVELOPMENT IN AN OPEN PLATFORM

Moderator refers to a variable that can alter the interrelations between other factors (Chaplin, 1991). Prior research done by Parthasarthy (2002) emphasised the importance of moderators in innovation development. His findings showed that the innovation process moderates innovation input (R&D related activities like sale and expenditure) and innovation outcome (number of launched innovations). Martínez-Sánchez et al. (2009), on the other hand, focused on the relationship between innovation performance and workplace flexibility. Their findings illustrate inter-organizational collaboration is an essential method for a company to expand its depth of knowledge about innovative goods and services. These studies have taking quantitative studies using moderation or regression analysis (e.g., Parthasarthy, 2002; Martínez-Sánchez et al., 2009). However, qualitative researchers such as Kohli and Joworski (1990) have used moderators in their studies. In this scenario, researchers directly ask their interviewees what factors moderate the relationship between innovation and performance for their developed products. Based on their answers, researchers form several moderators for their studies. Due to the focus and perception of this research, interpretive approaches have been used to find what factors have played the role of moderators in the study.

This research has identified two key factors that can make an enormous impact on innovation development: teamwork and feedback.

10.1.Teamwork

To build innovation and maintain it, organisations need to have a strong team and effective teamwork (West, Tjosvold, and Smith, 2005). This study showed two ways to create a strong and helpful team: regular meetings with this staff and meeting research projectors from outside. The following sections mention these points in detail.

10.1.1. Staff

Due to the newness of this platform, building and having a strong team is an essential element for developers. To have a successful development, co-operation and teamwork are vital (West, Tjosvold, and Smith, 2005). According to participants, having a strong team member has helped them face fewer technical errors and build a better project. In addition, a successful project has several positive outcomes. For instance, to get the full salary they have in the agreement, the team must meet the deadlines and provide the promised project to the customer. It is only possible when all staff members work effectively alongside each other. Also, customers' satisfaction with the project result has led to receiving bonuses on top of their salaries earlier.

"Only after we finish the project, we get out full salaries. Some clients gave us extra bonuses after they were happy with the result." — Participant 2

Moreover, participant 9 mentioned that his satisfied customers introduced more customers to him. Therefore, according to participants, "developing a strong team" has a direct positive relation with "relationship with customers". Through building a successful app, complementors have been to create strengthen the relationship with customers. This close relationship resulted in positive word of mouth and recommendation from customers. Lack of having access to customers is the most common issue that complementors of HoloLens face. Therefore, building a strong relationship with customers have been used as a strategy by complementors to not only get their feedback on the projects they are developing but also getting positive recommendations from them.

"Personal leadership style" has also been mentioned as key factor by participants 27 and 15. A leader can also have a direct impact on the outcome of the process. To have a strong team, members are expected to work on deadline as well as continuously communicating with customers and each other. Lack of leadership of staff members can stop the team from reaching their goals.

"Even people who would do very well in the team, if they have a bad leader, things could go completely wrong. They can loose any possibility they had of being a strong team and that can also affect the communication with the customers, if things start running late, if there's no clear

communication with the customers about what's being expected or anything like that deadline not being met. I think the style of the of the leaders is actually quite important in supporting everything else." — Participant 15

"In our company only our manager is in touch with customers directly. Therefore, we tend to have regular basis to set our weekly goals and make sure everyone is in a right track in the team. I think the role of leader is very essential because without of him they would be working on different areas that eventually will not be helpful towards the final goal at all." — Participant 27

Overall, due to the nature of HoloLens platform, complementors' have some difficulty finishing the result solely by themselves. Having a knowledgeable staff who has the required skills and knowledge can increase the chance of developing a successful app. A staff member with a leadership style can control the project's performance and keep the relationship with the client.

10.1.2. Project Researchers

Externally, complementors can also create teamwork with professionals such as project researchers outside of the organisation. As the technology used in HoloLens platform is new, complementors find it beneficial to work with a project researcher who would search for solutions and notify them about the latest updates and software programs. They can apply these to their projects. Before the start of a project, project researchers search and gather required and analyse the data. This action can minimise the number of potential errors in the production stage.

"Our project researcher handles the searching part of the work and then, in the meeting tells us about his findings. I would say our projects and jobs are in hands of the research department" — Participant 31

10.2.Feedback

In order to create and maintain a successful innovation, complementors are expected to receive constructive feedback from others. Feedback allows complementors to improve their development process and the decisions they take for the final project. This study identified four

types of feedbacks complementors could receive as moderator. The following sections discuss these points in further details.

10.2.1. Customer

Customers and their importance on innovation success have been mentioned previously. As a moderator, customer feedback plays a crucial role in innovation success, and its importance is unavoidable. Since apps are being developed and targeted towards single clients, complementors need to contact and stay in touch regularly. Complementor's ability to address customers' expectations and the issues raised by them previously in the project can increase the probability of their satisfaction with the final project.

"It's mainly just […] if they asking them what they like and how they like it and if we're on the right track […] it's just important to know their opinion" — Participant 15

There are multiple ways in contacting customers but to meet customers or potential customers feedback face to face, complementors have been attending workshops and event.

"Attending exhibitions and events help us to meet our target audience and potential buyers face to face. We let attendees to try our prototypes… this way we get their attentions about what we can offer, our talents… and through the discussions we have with them, we might be able to pursue them to work on a project with us and we develop an application for them." — Participant 3

However, there is downside to getting constant feedbacks from customers as it can result in not meeting the deadlines on time and facing issues with how they can plan ahead their schedules.

"It's when we have a lot of feedback it makes planning ahead more difficult so it's a negative relationship." — Participant 9

A moderate level of contact and relationship with customers is needed to result in having higher success rate.

10.2.2. Technicians

Technicians are workers who have intermediate skills (lewis, 2019). They can develop and disrupting innovation. Developers to deal with the complexity of software and hardware systems of HoloLens, they contact technicians to get their opinion on who they should approach development using provided systems. Ability to have access to technicians has allowed developers with finding the solutions for the issues they face and learn from their mistakes. However, finding the right technicians has been time consuming and costly for participant 11.

“The problem that I have with technicians is that having them smooth the process of development but finding the right one understand the programmes it's not easy. Microsoft doesn't provide Technical Support in my country. I'm finding the right person who has similar skills [but] is not very easy.” — Participant 12

Complementors by finding and contacting technicians can improve their product performance and fix any technical issues they might face. However, they need to be aware if the skills and knowledge of that chosen technician matches, they project they are developing. Wrong feedback can delay the process of development.

10.2.3. Students

To some developers, contacting students have been an easy and effective way to get their opinion about the prototype they have developed. Depend on the type of the project and technicality of it, participants have tried to contact the write students to get their feedbacks.

"The MVP I created, I tried to demonstrate it to college students […] you know, they are young and can give very critical feedbacks about the functionality of it. It helped us to save time and money. You know, prototypes cost money and to make a new one you need to have funds. Having other peoples to try the prototype apart from your customers help getting closer to the ideal design." — Participant 10

Though relying on feedback from students, complementors have been able to improve their project’s functionality as well as saving time and money. It is an approachable and easy way to get external opinion and view about the protype that has been developed.

10.2.4. Other Developers

This has been the most common way of getting feedback from external sources. By attending conferences, workshops, exhibitions, and events organised by HoloLens complementors have been able to show their prototype to other developers and get their opinion on it. Since, all complementors who attend the events or conferences uses the same device and similar software programs, attending these events allows complementors seek advice from other developers in the same or similar field of work and network with them.

"I bring my prototypes with me to events that I attend this way I can get some comments from other developers to see what they think about it. This way I both get some feedback for my project and make some questions with other developers at the same time." — Participant 31

The key different between getting feedback from student and other developers outside of the organisation is the level of technical knowledge. Complementors are advised to use more than one way to get feedback as each on of these four factors mentioned above perform better on one aspect:

- Customer feedback gives more critical feedback on the personalisation aspect of the project.
- Technicians' feedbacks help with technical issues complementors face during.
- Students' feedback can help with the functionality aspect of the project.
- Other developers' feedback can suggest alternative approaches based on past experiences.

Figure 10.1 adds all the above findings about the moderators of innovation success in relation to the possible consequences of successful development. complementors are advised to use one or more in the process of the product development.

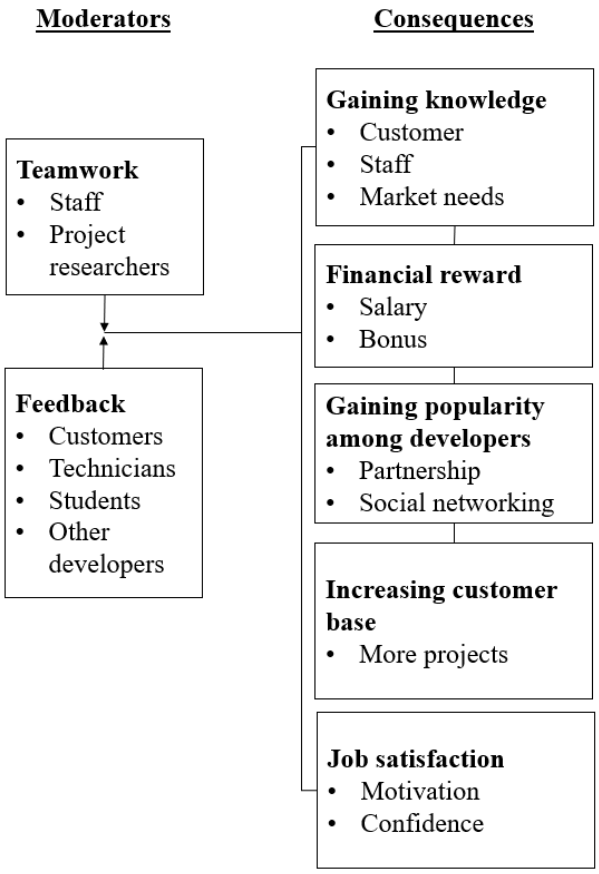

Figure 10.1: Incorporating the findings on moderators into the model

Summary

All the mentioned findings regarding antecedents, consequences, and moderators can be combined as one model with a comprehensive focus on what factors can create success in a new platform. This model has been built based on the results of data collection from HoloLens and shows the best fit to the findings of this research. Figure 10.2 combines figures of chapters 8, 9, and 10. This model suggests in order to create a successful innovation in such a platform, complementors need to depend on developing both strategy and objective. The antecedents and consequences of an innovation framework answer the last objective, which is to develop a

conceptual model of complementors' decision-making to achieve successful innovations in an open platform.

According to this framework, there are three critical antecedents in developing innovation in a newly opened platform: having access to resources, customers, and controlling human factors. Findings of chapter 7 indicated that according to participants, having direct access to customers allows them to build a relationship with customers and solve their problems. It happens through trying multiple prototypes in the development process. Having a high level of knowledge and experience about developing an application in open platforms increases the chance of accessing the market. This finding links to findings of the prior researchers in entrepreneurial alertness schemas, which indicates factors such as experience increases the chance of having a higher level of knowledge of the activity, self-effectiveness (Tang, 2008), conscientiousness (Lim and Xavier, 2015), and optimism and creativity (Ardichvili et al., 2003) in decision-making.

In this study, teamwork and feedback increase the chance of developing a more advanced and practical innovation. Teamwork elements also get linked to complementors ability to build effective networking with other software developers. Ardichvili et al. (2003) explain social networks as a component that determines the degree of entrepreneurial alertness in their prospective detection and growth framework as a component formed by creating relationships, cooperation, and participating in diverse activities. A more substantial level of networking increases the chance of developing successful innovation, and in this platform, project managers and knowledgeable staff play this role. Getting feedback from others, including customers, technicians, other developers in the platform, and students, can also increase the chance of innovation success.

The positive outcomes in this framework can be gaining more knowledge on customers, staff members, and the needs in the market. Moreover, having a successful experience in developing an innovation can increase account off getting financial rewards like bonuses. Having more experience developing successful innovations can also lead to gaining more popularity among developers and joining in father projects with others on this platform. Lastly, you can increase the chance of developers job satisfaction which increases their confidence level are motivated them to join further projects.

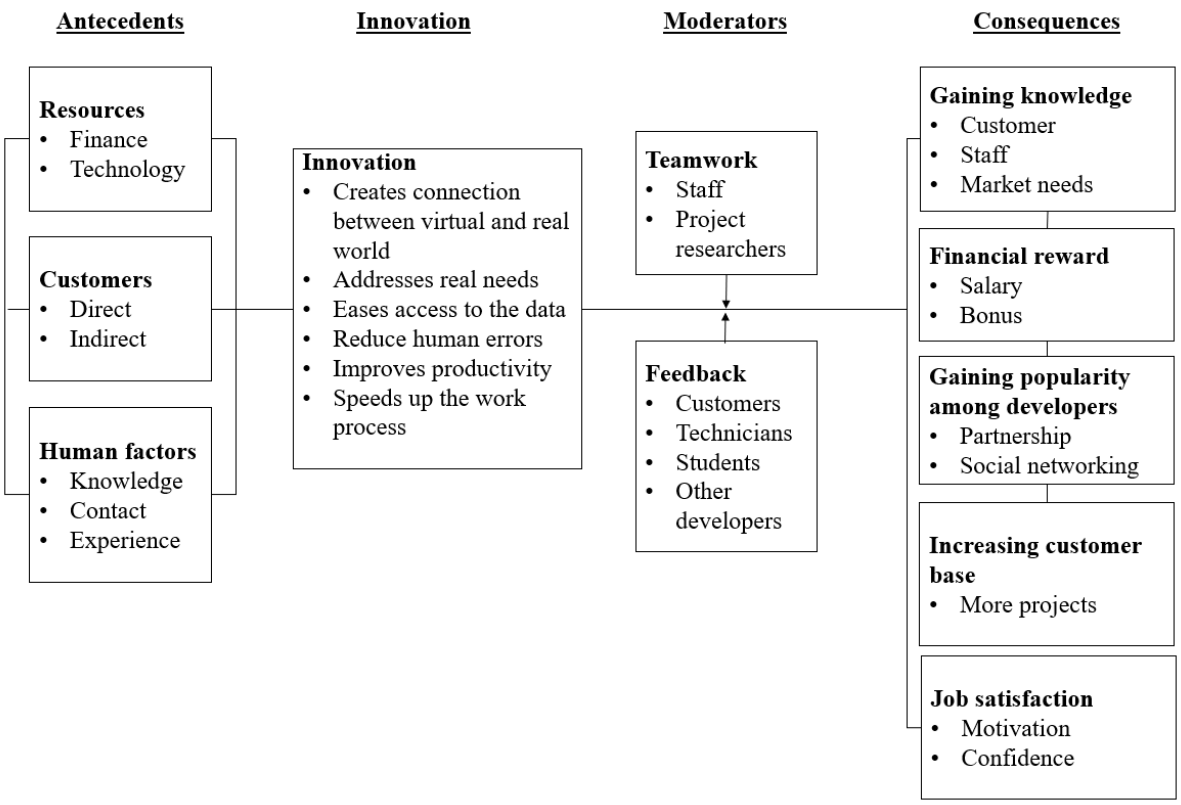

Figure 10.2: Antecedents and consequences of an innovation

CHAPTER 11

CONCLUSION

11.1. Summary

This research has contributed to the existing knowledge. The introduction section outlined the need for further investigation on complementors sensemaking of an open platform. It outlined the gap in lack of knowledge in understanding complementors' information processing and decision-making and their beliefs in the platform ecosystem. To address these issues, this research used an interpretive approach to get an in-depth insight into the beliefs complementors have regarding the platform in development.

Through the use of sorting techniques and cognitive approaches, this study has revealed a number of elements customers believe are essential to meet to reach success. For instance, this study found that complementors believe customers as one of the most influential factors in developing their complementary innovation. Due to the uniqueness of the HoloLens platform, developed apps tend to be targeted at a single customer or an organisation. Therefore, having access to customers became the most impacting factor for an innovation's success. Without it, complementors are unable to reach the final stages of their production. Having access to customers allows them to get a better understanding of their needs as well as the market's demands. Therefore, developers for success have a customer-centric approach in which they try to contact and get their feedback from early on in the platform. Findings also emphasised having a strong team and team works as these are also directly related to having innovative ideas and developing better designs.

Prior research emphasised stand-alone value as a strategy used by complementors when they decided to join a new platform with a low number of end-users. Although this theory explains the main reason for complementors to join is to escape the intense rivalry in platforms, it fails to explain how complementors deal with the ambiguity and complexity of a new platform. Moreover, there are no findings that would explain how complementors form their strategies to create a successful complement under these conditions. This study challenged this issue by introducing a conceptual framework that looked into the antecedents and consequences of

developing innovation in a new open platform. Findings highlight the resources, customers, and human factors are impactful antecedents that are essential to meet to guarantee success.

This research also found that developing an innovative application can be financial rewards, increasing customer base, gaining more knowledge about the environment, and job satisfaction. Based on how strong the consequences are, complementors are motivated and willing to develop further applications in the same platform. To guarantee this, complementors are required to focus on their teamwork and the feedback they would receive throughout development.

To understand complementors' cognition in making strategic decision-making, this study used an online cognitive mapping approach. It helped with getting a representation of developers' mental models about what factors they believe create success for their innovations and the relationships between them. The cognitive mapping approach has vastly been used to focus on managerial cognition studies and how managers deal with the complexity of new technologies and adopt them (e.g., Swan and Newell, 1994; Swan, 1997). For the first time, this study applies this approach to understand single developers in a platform better. Moreover, this research uses the cognitive mapping approach by applying it online via Google Docs and Skype. This study followed Combe (2006) by combining three cognitive techniques (laddering technique, cognitive mapping, and sorting technique) to get a comprehensive finding on complementors belief system about forming and making strategic decisions. These findings have made multiple contributions to knowledge.

11.2. Contribution to knowledge

11.2.1. Theoretical Contributions

The contribution of this thesis is mainly focused on the complementor sensemaking of the new platform. This research is the first to investigate the complement's beliefs about innovation development success in an open platform. There is no published literature focusing on complementors cognitive behaviour and sensemaking, especially in a recently opened platform. For instance, Song et al. (2018) is the first published literature that studies factors impacting complement's platform adoption. Its findings identified platform features, personal elements, social engagement, and the system's environmental impacts as impacting factors.

However, their paper defined and examined factors by creating variables based on published research rather than approaching complementors. Using secondary data collection resulted in ignoring the complementors perceptions and beliefs about the platform and its new technological features. This thesis started to address this issue by taking an interpretive approach. The findings of this study also highlight the importance of personal elements but add personal leadership style and learn from mistakes. These are important to adopt and develop an innovation in a new platform successfully.

Durbin (2016) and Dubrova (2019) highlighted the lack of a business model and its impact on complementors motivations and confidence to join a new platform and successfully develop an app for it. The conceptual framework developed in this research is based on complementors beliefs about impact factors and their consequences on innovation development in a new platform. The multiple case study conducted on complementors of HoloLens showed access to financial and technological resources, customers, developer's knowledge, contact and networking with other developers, and past working experience required for successful development. Getting feedback from customers, developers, and technicians can help maximise developing a successful application.

This study emphasises the importance of cognition and sensemaking in information management studies. However, prior studies have investigated individuals' innovation adopting behaviour using the adaption-innovation theory (Kirton, 1976). These studies focus was on the stability of cognitive style in adaption innovation (Foxall and Haskins, 1986; Kirton and De Ciantis, 1986). Since this study aimed to understand how people think by considering their perspective and how they perceive and understand content at all levels, cognitive content fitted the perception of this study. However, no prior studies have been done focusing on complementors sensemaking in a new platform. The findings of this study have added a new perspective using cognitive content.

According to previous research, complememtors' decisions are influenced by the platform's openness and the regulations and governance norms it establishes for third-party developers (Wessel, Thies, and Benlian, 2015). The HoloLens device's architecture means that its technology and created applications are exclusively aimed at experts, limiting the device's ability to reach a vast number of people. The findings on comeplementors intention to join a

platform based on previous work experience are consistent with the results of Song et al. (2018) study, which believes that social engagement and network effect have influenced the acceptance rate of technology and innovation (Lu et al., 2005) as well as the entrepreneurial alertness theory's network connections factors (Khakbaz, 2012). According to these results, through network effect, complementors can increase their knowledge and purpose on a new platform and under uncertainty by using network effects.

According to the findings of this thesis, the most effective and significant aspect has been the importance of having customer connections. It contradicts previous research findings as it suggested that complementors' experience is the most critical component for complements in a new platform (Bassellier et al., 2001; Teece et al., 1997; Thong, 1999). The key reason for this disparity has been the HoloLens platform's uniqueness, which allows every app to serve just one client or enterprise. This distinction has shifted individuals mental models based on their previous experiences on other platforms. Design and service quality was mentioned as the second and third most important factors impacting innovation success in an open platform. These factors are connected to complementor knowledge. This finding supports the entrepreneurial alertness theory, which states that managers' basic knowledge of the activity, management talents, and professional experiences have a powerful effect on their decision-making (De Jorge Moreno and Victoria, 2008).

11.2.2. Methodological Contributions

This thesis has extended the knowledge about cognitive mapping methods introduced by (Markóczy and Goldberg, 1995). This method has been used to understand managerial, strategic decision-making and policy development research (Ackermann and Eden, 2011; Schwenk, 1988; Huff, 1990; Lowstedt, 1985), focusing on managerial cognition. They aimed to understand managers beliefs and factors influencing their technology adoption. This study has extended the knowledge of methods for investigating managerial and individual sensemaking by implying it to individual developers in open platform studies. Also, this study has added more factors to the pool of contrast based on repeated pilot studies used before final data collection.

Moreover, this research has taken a new approach in collecting data using online techniques. Due to the difficulty in finding participants working in the HoloLens platform inside the UK,

this study developed a new data collection approach using an online platform to approach more complementors. This created an opportunity to expand the sample size with broader coverage. In this approach, both the sorting technique and questionnaire were uploaded online on Google Docs before the interview. Since the participants of this study were working for a software platform, they expected to know how to work with the Word and PowerPoint programs. Therefore, no prior description regarding how to use word or Powerpoint online was given to participants.

11.2.3. Practical Contributions

The practical contribution of this study focuses on complementors who are or willing to work in a recently established platform such as HoloLens. As discussed in chapter 6, not many participants are enthusiastic about joining and developing complements for a new platform. A platform similar to HoloLens involves a high level of complexity in both the technology it offers and how its end-users are approached. Moreover, there is a lack of a reliable business model, resulting in third-party developers facing issues choosing the right strategies to develop their products (Durbin, 2016). The findings of this thesis have provided active and potential complementors of this platform with a clear view of how they can succeed and what to expect after joining such a platform.

The conceptual model developed in this thesis is based on success factors mentioned by complementors. It highlighted antecedents that are required to be met to guarantee success in the platform. Resources is the first antecedent mentioned in this research. It refers to the elements that are used by complementors to function effectively in the platform. Finance is the first factor and one of the most essential elements mentioned by participants that future developers need to be aware of. It highlights the importance of having money and financial support for the development of a mixed reality app. Therefore, active and potential complementors need to have a clear financial strategy to manage this factor.

According to participants, the type and location of suppliers, number of application features, API, design, and the number of platforms the developed app wants to be used are the factors that complementors must be aware of when deciding to develop their apps. In addition, planning ahead and the leadership style of complementors allows them to manage the

production costs and generate profit. With consideration of these factors, developers can guarantee and improve the chance of developing a successful product.

According to participants, having access to vital and relevant technological resources increases the chance of developing a more advanced app. In the HoloLens platform, accessibility to the software programs used is the HoloLens headset and Android and Windows Store. Holographic Applications require software programmes that would take control of Windows Holographic API. The Unity Framework is preferred for designing 3D applications but not essential. It is essential to check the usability and accessibility of the app using these software programs to assure the app's success. As the technology used is moderately advanced, it is required to be checked with the client to make sure he/she can adopt and use it. Since it can be very costly, clients expect high quality and functional apps. Therefore, complementors must have a clear production plan to guarantee the app is being developed on schedule and is not facing any errors.

Another factor complementors need to consider to develop a successful app is customers. As this platform targets professionals and the device it is offering is very costly, it is not targeted towards average end-users. There are two ways in getting access to the customers: direct approach and indirect approach. The direct approach refers to having access to customers from the beginning. To meet customers directly, past working experience, knowledge, and skill are essential. Some of the participants got approached by customers due to their reputation. Their past working experience was about a field like construction which allowed them to have the required knowledge to both create a functional app and contact customers directly.

The indirect approach refers to meeting customers through either recommendation from other customers or online and offline marketing techniques. For indirect approach, exhibitions, conferences, events, and workshops are where they meet their customers. Before deciding to develop an app in the HoloLens platform, complementors need to decide which of these two factors fit their situation more.

Another primary antecedent is the human factor which contains knowledge, contact, and experience elements. Knowledge refers to complementors' level of understanding about the platform and its new features. Percipients stated that past working experience in IT sectors helped them with adopting HoloLens new software features. Other participants emphasised

developing and having a strong team as having strong team members can enhance the app's quality. Overall, factors that affect the knowledge quality have skilled team members, getting feedback from customers regularly, and platform complexity for developers. Therefore, it is advised that potential developers gather all the required knowledge about the platform regulations and architectural design before joining in.

Contact is another antecedent of this study, and it refers to having contact with customers and other developers throughout the innovation development. According to participants, this action can meet the client’s expectations, make fewer errors, develop a prototype, and test it out of regulation. The client can play a huge role in developing successful innovation.

Past working experience is also impactful in the outcome of the product performance. Although some participants mentioned they joined the platform with the sole purpose of gaining experience about such a new platform, for staying and continually developing apps, complementors are required to have some level of knowledge about the software and features of the new platform. Potential developers should be aware that all the antecedents mentioned above are required to develop a successful innovation that can answer real needs, face fewer errors, speed up the work speed, and get easy access to data.

This conceptual framework also covers the most frequent consequences of developing a successful app mentioned by complementors. By developing a successful app, participants have been able to get more knowledge about the market they were targeting, its customer's expectations and needs, and the staff and other developers working in the same field. Having a higher number of finished projects does help complementors gain more popularity among developers and get more project offers. It can also depend on customers' positive comments or recommendations. Customers may give financial rewards like bonuses to complementors if they are happy and satisfied with the project outcome.

To increase the chance of developing a solid project, complementors need to work effectively with their team members and project researchers outside the organisation. Building a positive relationship with them can lower the probability of facing technical errors or failed projects. Feedback is also believed as one of the most impactful factors, according to participants. Therefore, Having this ability to get feedback from other developers, customers, or technicians on the projects they develop will increase the chance of having a successful final project.

11.3. Limitations

Despite this research aimed for a comprehensive and detailed design, it faced unavoidable limitations which needed to be addressed.

In designing a research strategy, case studies are commonly associated with being very specific and lacking generalisation. This issue results in questioning the ability of the outcomes to fit the other scenarios. Multiple case study is also not an exception as the outcome highlights a unique result. As this study aimed to focus on a newly opened high-tech platform, this case study fitted the objectives of this study. Gustafsson (2017) mentioned multiple-case designs tend to be very time consuming and costly to be conducted. This was not an expectation for this study. This study used an online platform to conduct the interviews and collect data to avoid this issue. Using Google Docs for sorting techniques and questionnaires and skype interviews allowed this study to conduct complete data analysis.

Another limitation in this study was dealing with the pool of constructs mentioned in the research done by Buzzell, Gale, and Sultan (1975), Markóczy and Goldberg (1995), and Walsh (1988). Not all factors resonated well with the focus of this study which focuses on complementors strategic decision-making and information processing in a new platform. Therefore, this study first simplified the factors mentioned in the previous studies. Then through conducting three rounds of pilot studies, this research was able to add more relevant factors and test them before conducting the actual data collection. This study gave a complete overview of developers' activities in a new innovative platform by conducting the final data collection.

Also, the cognitive mapping approach has certain drawbacks. It may be lacking if the mapping data is not utilised combined with other approaches to augment or clarify relationships and themes. As Mannion et al. say, there can be a risk in such maps, notwithstanding their biased representations of reality, that might be seen as complete and definitive (Mannion et al., 2004). Similarly, these cannot be counted as models of cognition that indicate the way people evaluate knowledge (Axelrod, 1976; Eden, 1992), but instead portrayal of tacit knowledge during one point in a particular time in a specific situation.

Lastly, the newness of the platform and its focus on targeting professionals resulted in having a lower number of participants who can successfully participate in the platform. This issue resulted in not finding many active developers who would be willing to participate in this study. Conducting online interviews and data collection allowed this study to approach more active developers globally. However, the number of developers who could participate in this study was limited due to the language barrier. Also, since apps being developed are only targeted towards a single client or organisation, it limits the willingness of participants to talk about the details of the projects they are working on or go into further details in their answers. By assuring participants that the details of the discussions will stay confidential and only certain parts of their interview transcripts would be published, this study was able to gain the participant's trust and conduct the entire data collection.

11.4. Future research

This thesis has been able to provide several opportunities for future studies. The points being raised are aimed to prospect additional research on complementors strategic decision-making in an open platform.

Firstly, a longitudinal study can be used to get further insight into how complementors' beliefs changed over time as the HoloLens platform ages. This study followed one round of data collection due to factors such as the newness of the HoloLens platform, having one product (headset) introduced into the market, and only targeting specialists, which results in having a lower number of users and complementors to participate. The longitudinal study allows future researchers to understand what the changes in a developer's belief system are. Furthermore, having more data collection rounds helps them find what has changed in the success factors rankings. In other words, which factor has topped the ranking chart and lost its level of importance over time. Through this, researchers can study the cognitive shifts in complementors' information processing and decision-making.

Personality and cognitive style were not studied in this research. However, in the research of rising degrees of cognitive changes, these can become important to be studied. According to Dane (2010), studying personality factors including willingness to learn and cognitive styles can function as precursors of cognitive flexibility. A further topic of interest that is becoming more significant is the function of emotion in cognition. Emotion is expected to substantially

influence, especially during changes in environmental surroundings (Kaplan et al., 2013). Consequently, that may be necessary to investigate if cognitive changes are influenced by emotional and logical cognition (Fiol and O'Connor, 2002).

Secondly, future researchers can use alternative perspectives to investigate complementors' belief systems. Although this research had a micro-level perspective, the data gathered revealed details of broader scale insights. Variables such as country of origins were not considered in this thesis due to the limitation in having active developers in the platform at the time of data collection. As environmental complexity (heterogeneity) and variability (dynamism) can impact an individual's decision-making and information processing, it is expected to see differences in complementors beliefs based on their cultural background and the operational policies they follow. Future researchers can take this study further by doing data collection considering this variable. By grouping the complementors based on the countries they live in and doing a cross-cultural study, researchers can understand the homogeneity and heterogeneity in their interests and beliefs related to app development in the new platform ecosystem. Through this, future researchers can better understand similarities and differences in developers' mental models.

Thirdly, different choices of methodology can tackle developer's information. This study aimed to get in-depth insights about how complementors make sense of a new innovative platform and what factors they believe could lead to success for them. Therefore, the interpretive approach did fit the notion of the study. Future research by taking a mixed-method approach can expand the findings by testing the conceptual framework. Using a hypothesis and a range variable, this method can test the power of each antecedent. This action can help complementors with getting a more accurate view of which factors were used in strategy development and its level of success in forming a competitive advantage.

Testing the power of mediators can increase the chance of innovation success in this platform. At the moment, the importance of teamwork and staff in boosting innovation success has been studied as a mediator in prior studies using quantitative methods (e.g., Parthasarthy, 2002; Martínez-Sánchez et al., 2009). However, the importance of these moderators has not been tested in platform ecosystem studies. Further research can investigate which moderators mentioned in this study (power of staff and external project researchers in teamwork and

customers, other developers, technicians, and student's feedback) can have the most vital relationship with creating successful complementary innovation.

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APPENDIX

1) Sorting factor file used on Google Doc for the interviews

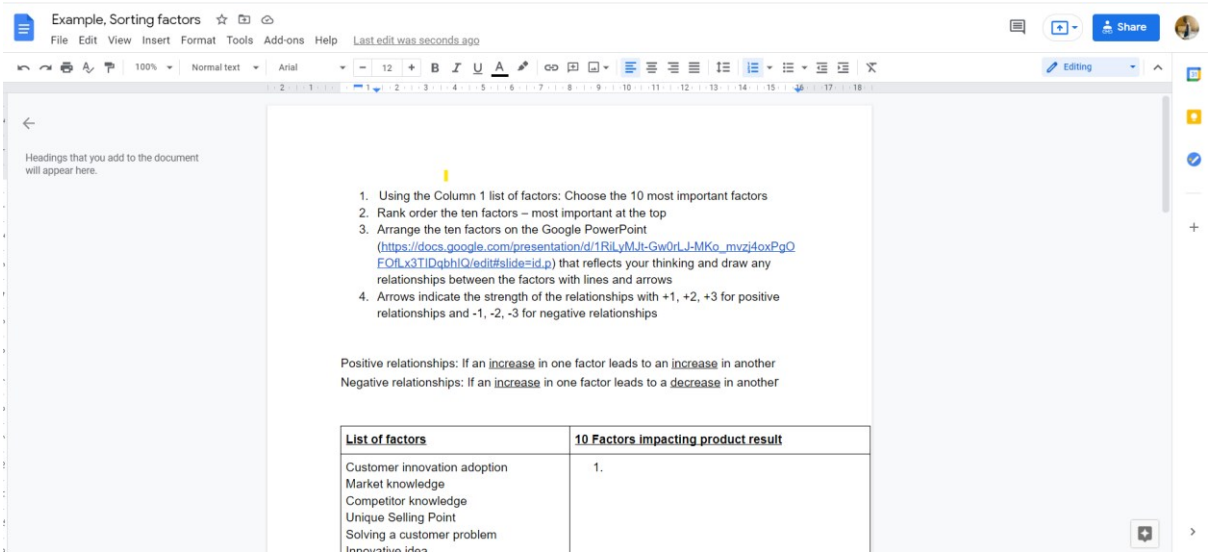
1. Using the Column 1 list of factors: Choose the 10 most important factors.
2. Rank order the ten factors – most important at the top.
3. Arrange the ten factors on the Google PowerPoint (https://docs.google.com/presentation/d/1RiLyMJt-Gw0rLJ-MKo_mvzj4oxPgOFOfLx3TIDqbhIQ/edit#slide=id.p) that reflects your thinking and draw any relationships between the factors with lines and arrows.
4. Arrows indicate the strength of the relationships with +1, +2, +3 for positive relationships and -1, -2, -3 for negative relationships.

Positive relationships: If an increase in one factor leads to an increase in another
Negative relationships: If an increase in one factor leads to a decrease in another

List of factors	10 Factors impacting product result
Customer innovation adoption	
Market knowledge	
Competitor knowledge	
Unique Selling Point	
Solving a customer problem	
Innovative idea	
Identify and recruit partners	
Design	
Prototype	
Relationships with customers	
Develop a strong team	
Analysis of product/service benefit	
Continually develop product/service	
Employees stake in the company	
Identify and obtain human resources	
Advertising	
Identify distribution channel/s	
Service quality	
Existing competition	
Barriers to entry	
Trademark protection	
Web site	
Patent protection	
Social media	
New entrants	
Clear processes	
Route to market	

Cash Flow Performance metrics Additional benefits to product/service Balancing risk Support from the company Learn from mistakes Support network Agility Responsiveness Relationships with suppliers Trial and error in decision-making Differentiation of product/service from competitors Personal leadership style Personal motivation Silo thinking Developing staff Planning ahead Learning to improve Barriers to change within the organization Timing of product/service introduction Employee flexibility Production facilities Accessibility to resources Motivation of staff Price	

2) Example of an empty sorting technique file on Google docs



3) Questionnaire form

Questionnaire. The information given in this questionnaire will be regarded as confidential.

1. Demographics

What is your job title?

_____

How long have been working as an app developer?

_____

Company name

_____

Company location

_____

2. Product development decision-making

Please state your attitude to the statements by ticking the appropriate box

	Completely false		Neither		Completely true
	-2	-1	0	+1	+2
I don't like to have the responsibility of handling a situation that requires a lot of thinking.					
I would prefer complex to simple problems.					
I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.					
I find little satisfaction in deliberating hard and for long hours.					
Thinking is not my idea of fun.					
The notion of thinking abstractly is not appealing to me.					
I prefer my life to be filled with puzzles that I must solve.					
Simply knowing the answer rather than understanding the reasons for the answer to a problem is fine with me.					
I don't reason well under pressure.					
The idea of relying on thought to make my way to the top does not appeal to me.					
I prefer to talk about international problems rather than to gossip or talk about celebrities.					
Learning new ways to think doesn't excite me very much.					
I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.					
I generally prefer to accept things as they are rather than to question them.					
It is enough for me that something gets the job done, I don't care how or why it works.					
I tend to set goals that can be accomplished only by expending considerable mental effort.					
I have difficulty thinking in new and unfamiliar situations.					
I feel relief rather than satisfaction after completing a task that required a lot of mental effort.					
My initial impressions of people are almost always right.					
I trust my initial feelings about people.					
When it comes to trusting people, I can usually rely on my "gut feelings."					
I believe in trusting my hunches.					

I can usually feel when a person is right or wrong even if I can't explain how I know.					
I am a very intuitive person.					
I can typically sense right away when a person is lying.					
I am quick to form impressions about people.					
I believe I can judge character pretty well from a person's appearance.					
I often have clear visual images of things.					
I have a very good sense of rhythm.					

3. App development

Please list three words that best describe the app

1.
2.
3.

Please list the factors influencing your product result

1.
2.
3.
4.

4. Commercialisation of the innovation

Please list the **ways** you achieve increasing awareness about your product online (rank the most important first):

1. 2.
3. 4.

Please list the ways you achieve increasing awareness about your product offline (rank the most important first):

1. 2.
3. 4.

5. Stakeholders

Rate the percentage importance of stakeholders to the successful exploitation of innovation. Taken together they need to add up to 100%

Customers	Suppliers	Competitors	Local Authority/ Government	Employees	General Public	Other *	Total
%	%	%	%	%	%	%	= 100%

*Please specify: …….

6. Objectives

Please list three of the most important objectives which require to be met to successfully exploit your innovation (rank the most important first):

1.
2.
3.

7. Competitors

Please list your three most important competitors (rank the most important first):

1.
2.
3.

Please list three factors that differentiate your innovation from your competitors (rank the most important first):

1.
2.
3.

Which best describes the level of client knowledge about your products – tick box

Higher than competitors'	
Same as competitors'	
Lower than competitors'	

Which best describes the level of clients' belief about your product– tick box

Higher than competitors'	
Same as competitors'	
Lower than competitors'	

Which best describes the innovativeness of your products – tick box

Higher than competitors'	
Same as competitors'	

4) Information sheet

Interview Participant Information Sheet

Decision-making in Platform Leadership: The Case of App Developers

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Research purpose:

For this research, I aim to collect a set of cognitive mapping from the app developers and influencers of Microsoft HoloLens. The purpose is to investigate the beliefs and their relationship to decision environments in the platform ecosystem, the decision-making of managers of innovation, and the consequences in terms of innovation success. It will focus on how individuals view the innovation.

It will involve a few cognitive tasks leading to a cognitive map being produced. This will be followed by an interview to discuss the map, the innovation, and the current environment. This will probably also include discussions around the process of development of the innovation.

Invitation to participate:

You have been chosen to take part in the study as you have experience of working as an augmented reality or MR app developer for HoloLens device. This research is aiming to interview 31 participants.

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason'.

Data collection and confidentiality:

In this research, I will be asking you to provide your opinions, beliefs and information on Microsoft HoloLens device and the apps been developed for this device.

There are no disadvantages in participating in this study. The data in your interview will be collected anonymously. It will be stored in a secure server separate from any database that will refer to your identity. In the storage, all the anonymous data will be secured by password that can only be accessed by me and my supervisors. Should any reference to made to your data in the research report, it will be made using pseudonym to protect your anonymity, without specific reference to your unique identity.

Herewith, I would like to request your approval for this interview to be recorded using a choice recorder. This voice recording is used so that more accurate data can be documented. If you are not comfortable for me to record the interview, I would like to request your approval to take notes of your answers.

The physical audio recording and/or notes will be kept for the period of two years and electronic audio files will be put into storage on a secure server for a period of three years, after which they will subsequently be destroyed. This is part of the requirement for the academic audit of research.

I am conducting the research as a research student in Marketing and Strategy Department at Aston University. This research protocol has been reviewed and approved by the University Research Ethics Committee, Aston University.

Research Output:

The research output will be presented as a PhD thesis, presented at conferences, published in academic publications, and potentially presented to Microsoft HoloLens for improvement in the future operations.

Your Rights:

As this research is voluntary, you may choose not to participate in this interview. Rest assured that your co-operation or non-co-operation in this interview will not be affecting your position. The interview will only be recorded upon your acceptance. If required, you can ask for the recording of this interview which will be provided to you in the form of a digital copy.

If you decide to participate in this interview, please kindly provide your consent by signing the consent form provided. Should you require any clarification on the study, you can ask me directly or send your question to my e-mail, which will be provided herein. You can withdraw your participation up to the end of November, after which the data will be studied in analysis.

If you have any concerns about the way in which the study has been conducted, you should contact the Secretary of the Aston Business School Research Ethics Committee on: abs_aarm@aston.ac.uk.

Thank you very much for your time and participation.

Doctoral Researcher:
Mahrokh Roknifard
Marketing and Strategy Group
Aston Business School
Aston University
Birmingham
B4 7ET
Email: roknifam@aston.ac.uk
Mobile: +44(0)121 204 5463

Research Supervisor:
Dr. Ian A. Combe
Marketing and Strategy Group
Aston Business School
Aston University
Birmingham
B4 7ET
Email: i.combe@aston.ac.uk
Mobile: +44(0)121 204 3181

Date: 2019-20

Aston University takes its obligations under data and privacy law seriously and complies with the General Data Protection Regulation ("GDPR") and the Data Protection Act 2018 ("DPA"). Aston University is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study. Aston University will process your personal data in order to register you as a participant and to manage your participation in the study. It will process your personal data on the grounds that it is necessary for the performance of a task carried out in the public interest (GDPR Article 6(1)(e). Aston University may process special categories of data about you which includes details about your health. Aston University will process this data on the grounds that it is necessary for statistical or research purposes (GDPR Article 9(2)(j)). . Aston University will keep identifiable information about you for 6 years after the study has finished.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally identifiable information possible. Individual studies may provide you with a time period after taking part in the study where you are able to withdraw data that has not been anonymised. This time period will be specified in the participant information sheet for the study.

You can find out more about how we use your information at www.aston.ac.uk/dataprotection or by contacting our Data Protection Officer at dp_officer@aston.ac.uk.

If you wish to raise a complaint on how we have handled your personal data, you can contact our Data Protection Officer who will investigate the matter. If you are not satisfied with our response or believe we are processing your personal data in a way that is not lawful you can complain to the Information Commissioner's Office (ICO).

5) Consent Form

Decision-making in Platform Leadership: The Case of App Developers

Consent Form

Name of Chief Investigator: Mahrokh Roknifard

Please initial boxes

1.	I confirm that I have read and understand the Participant Information Sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without my legal rights being affected.	
3.	I agree to my personal data and data relating to me collected during the study being processed as described in the Participant Information Sheet.	
4.	I agree to my GP being informed of my participation in the study.	
5.	I understand that if during the study I tell the research team something that causes them to have concerns in relation to my health and/or welfare they may need to breach my confidentiality.	
6.	I agree to my interview being audio recorded and to anonymised direct some quotes from me being used in publications resulting from the study.	
7.	I agree to the focus group being audio recorded and to anonymised direct some quotes from me being used in publications resulting from the study.	
8.	I agree to study visits being video recorded.	
9.	I agree to my anonymised data being used by research teams for future research.	
10.	I agree to my personal data being processed for the purposes of inviting me to participate in future research projects. I understand that I may opt out of receiving these invitations at any time.	
11.	I agree to take part in this study.	

_____ _____ _____

Name of participant Date Signature

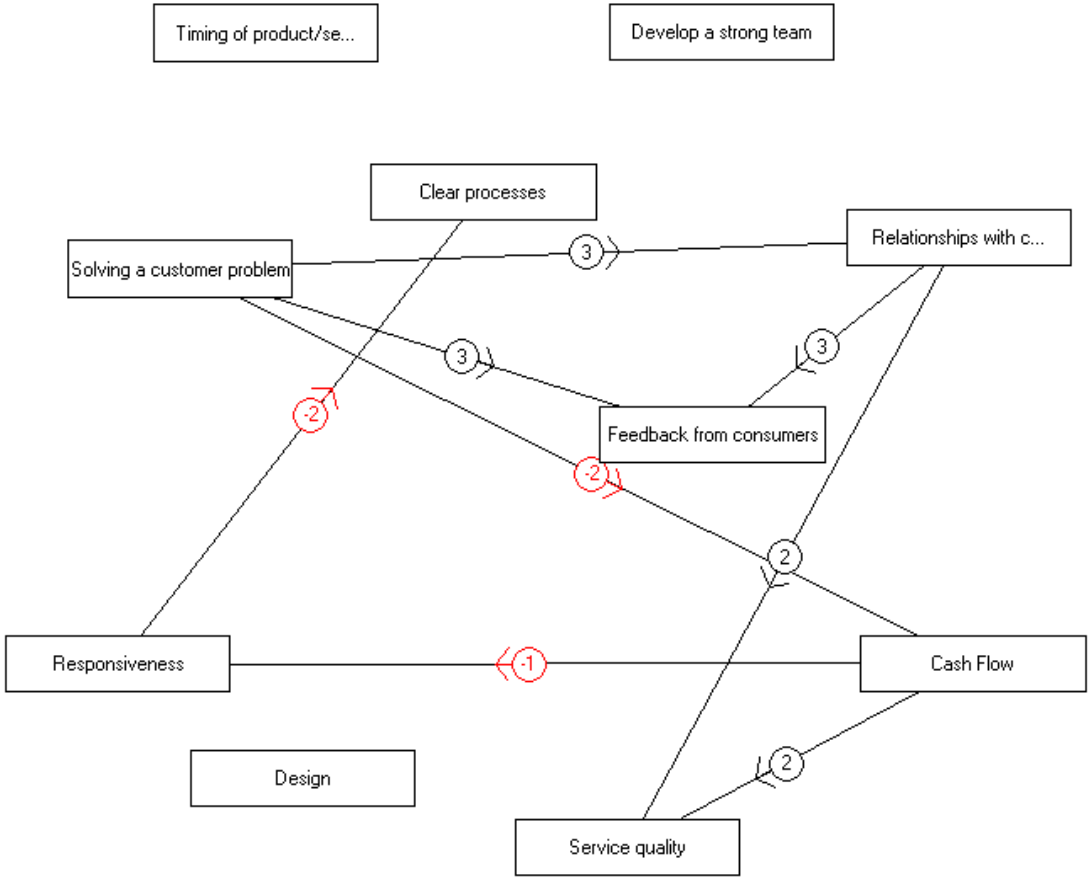
_____ _____ _____

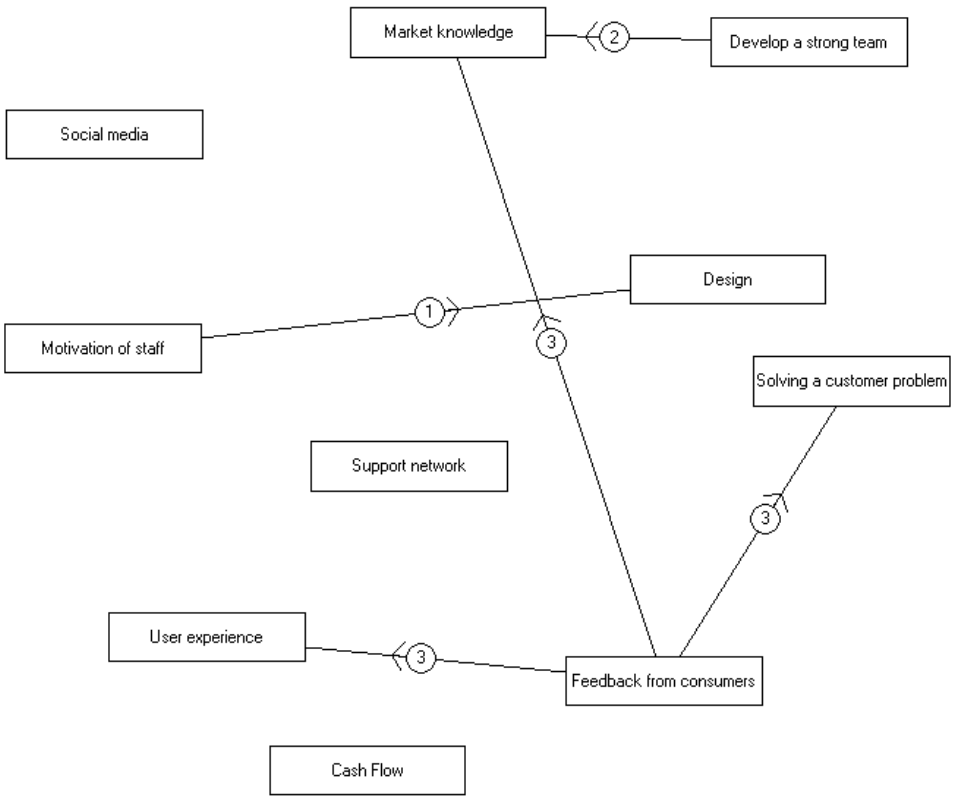
Name of Person receiving Date Signature

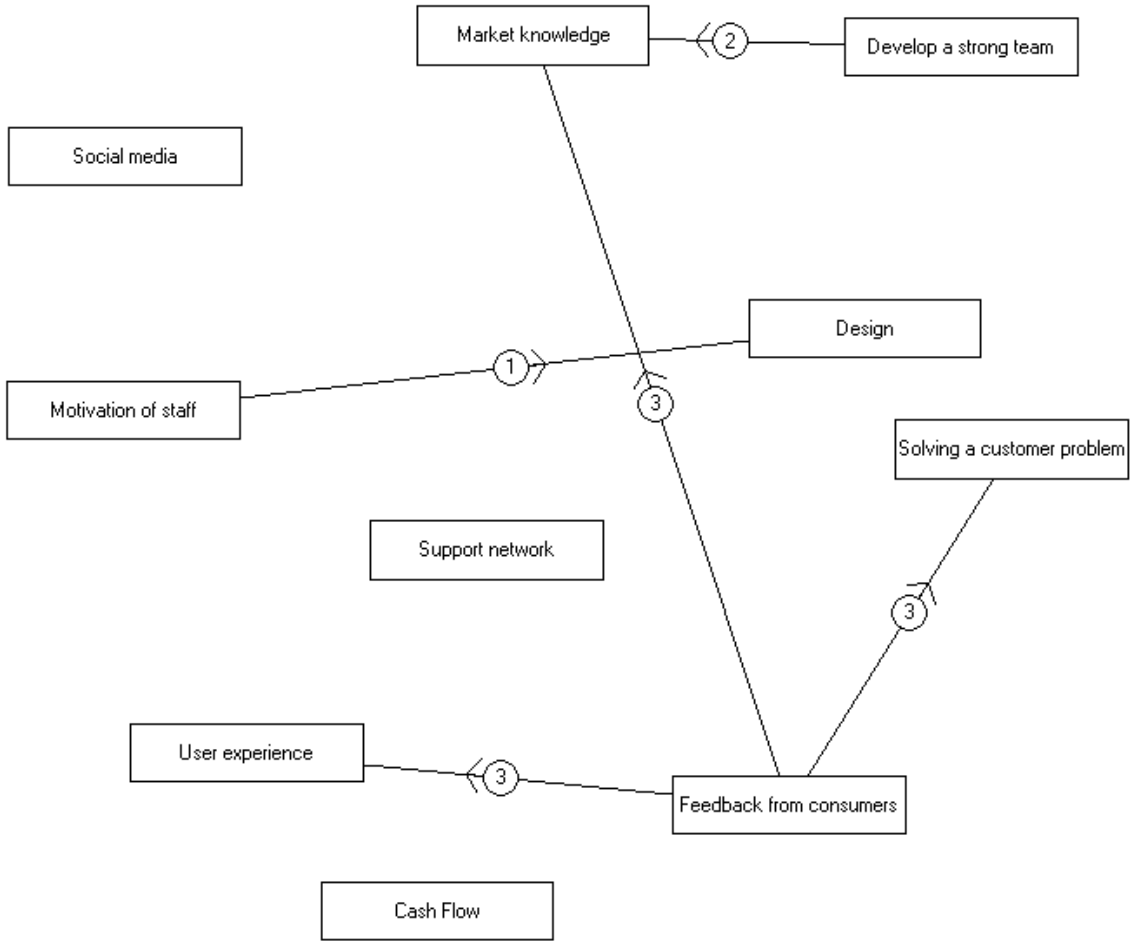
6) Core concepts used at the HoloLens platform (Microsoft, 2019).

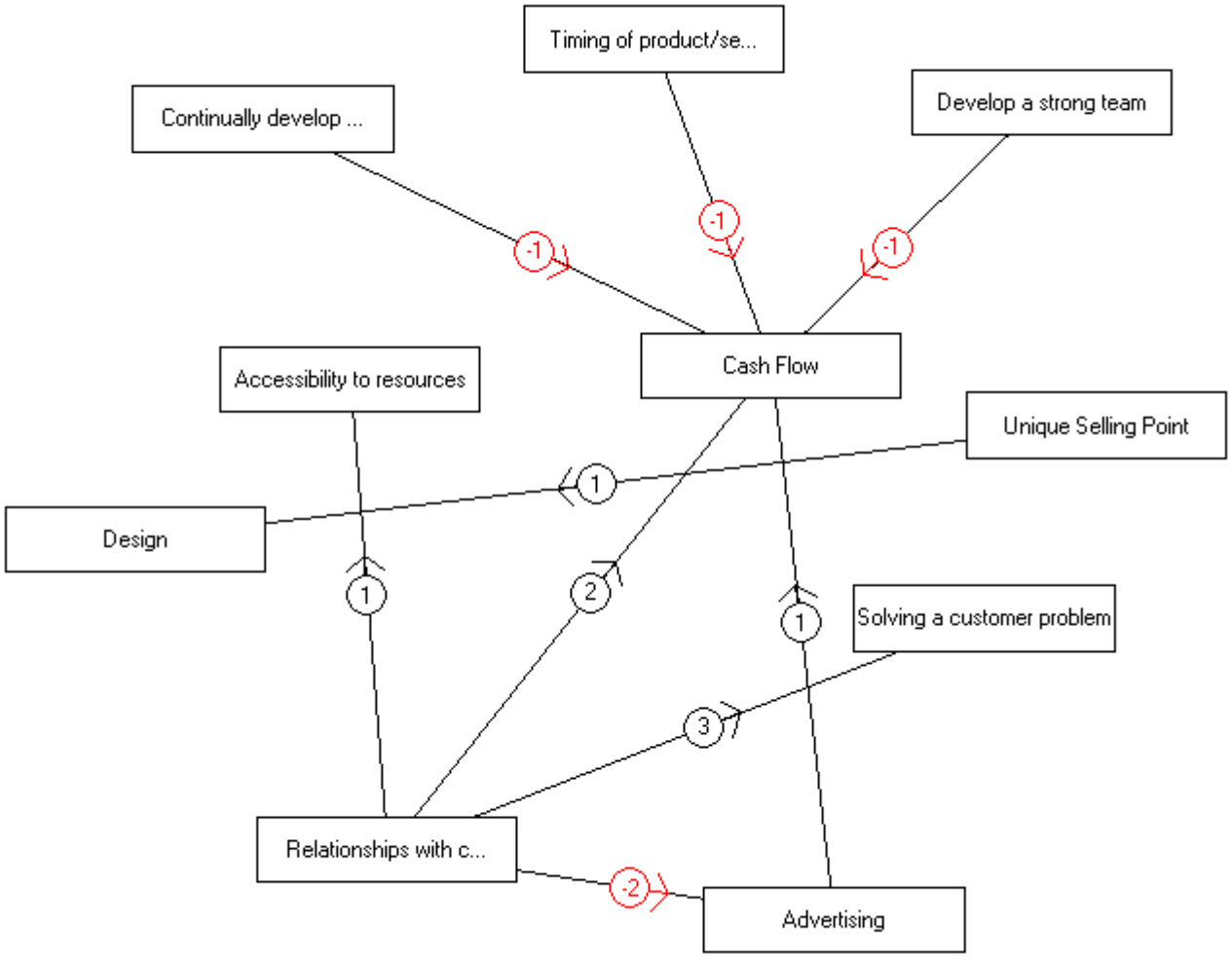
Concept	**Outcome**
Holographic frame	*"Understand how users see your content overlaid onto the real world when wearing their headsets"*
Coordinate systems	*"Learn how to position holograms in meaningful places in the world, whether it's their physical room or a virtual realm you've created"*
Spatial mapping	*"Anchor objects in the user's world and take advantage of real world's physical surfaces"*
Comfort considerations	*"Ensure user comfort and safety by creating and presenting immersive content in a way that mimics the natural world"*
Interaction models	*"Provide your users with instinctual interactions through hand, eye, and voice input"*
Hands and motion controllers	*"Learn how to interact with holograms at close range with a user' hands or at long range with precise interactions"*
Voice input	*"Use voice commands as input in your immersive apps to control surrounding holograms and environments"*
Eye Tracking	*"Add a new level of context and human understanding in a holographic experience by using information about what your users are looking at"*
Common controls and behaviours	*"Learn about frequently used spatial interactions and UI building blocks"*
Colour, light, and materials	*"Design quality assets for MR that take colour, lighting, and materials into account"*
Object scale	*"Incorporate as many real-world visual cues as possible to us help your users understand where objects are, how big they are, and what they're made of"*
Typography	*"Use clear, readable text in three-dimensional space to give your users the important information they need"*

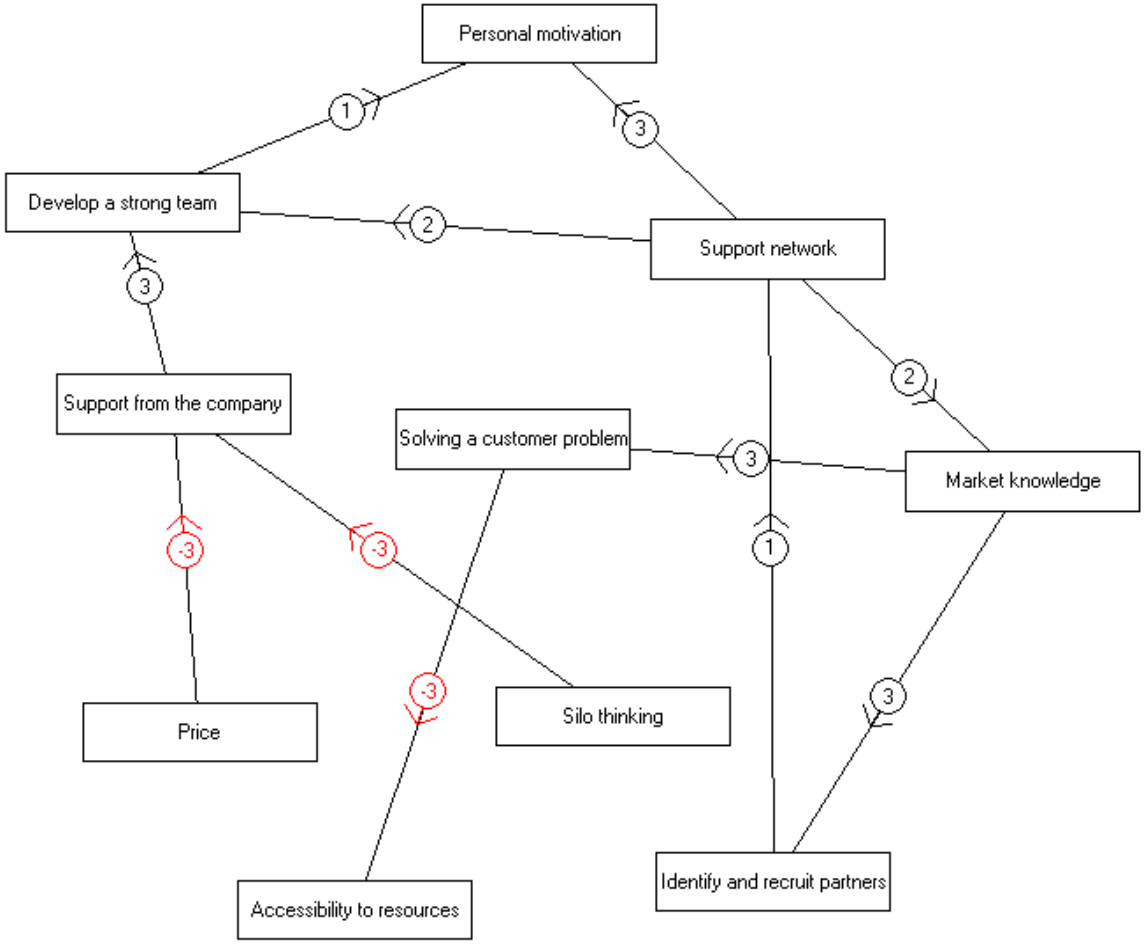
9) Participants cognitive maps in order

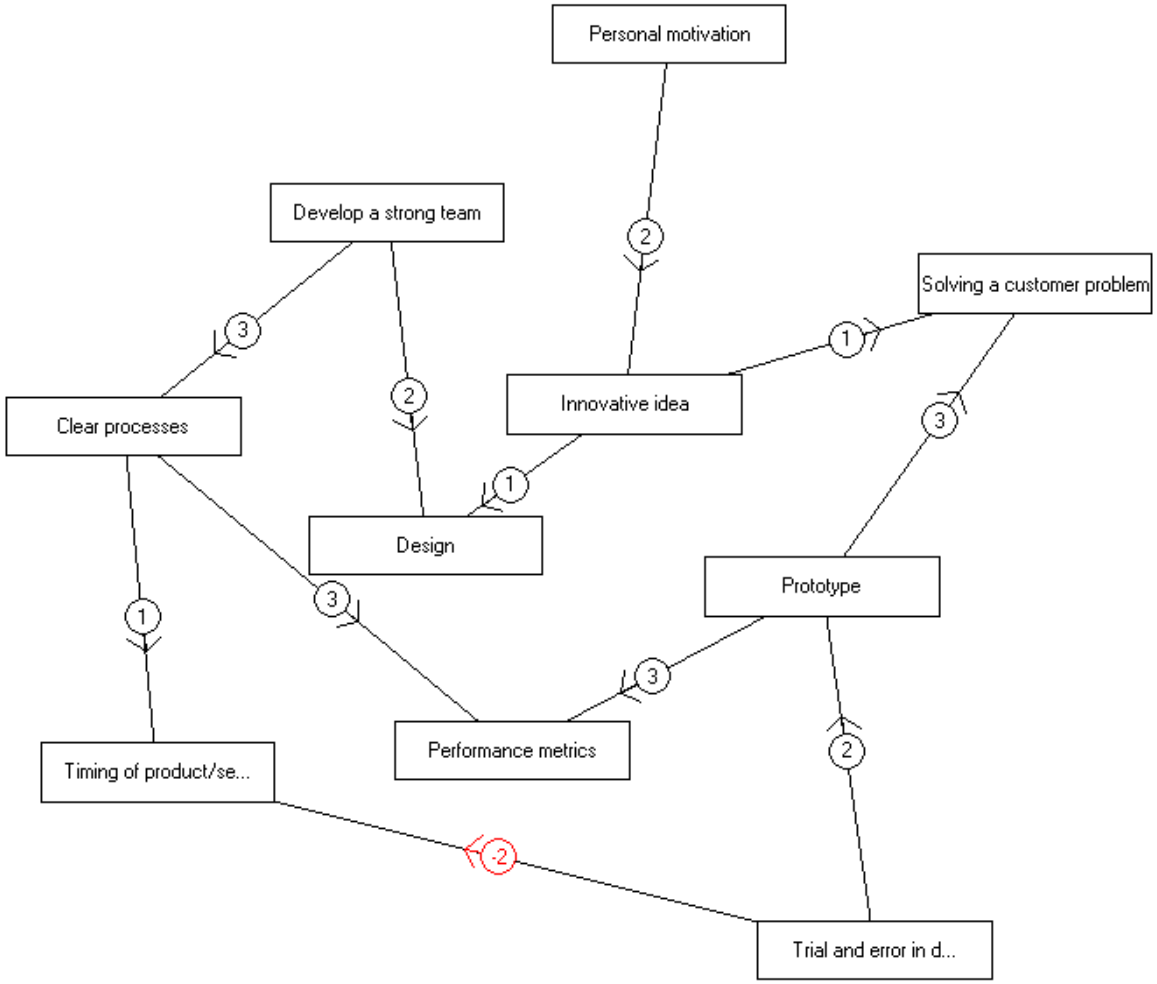


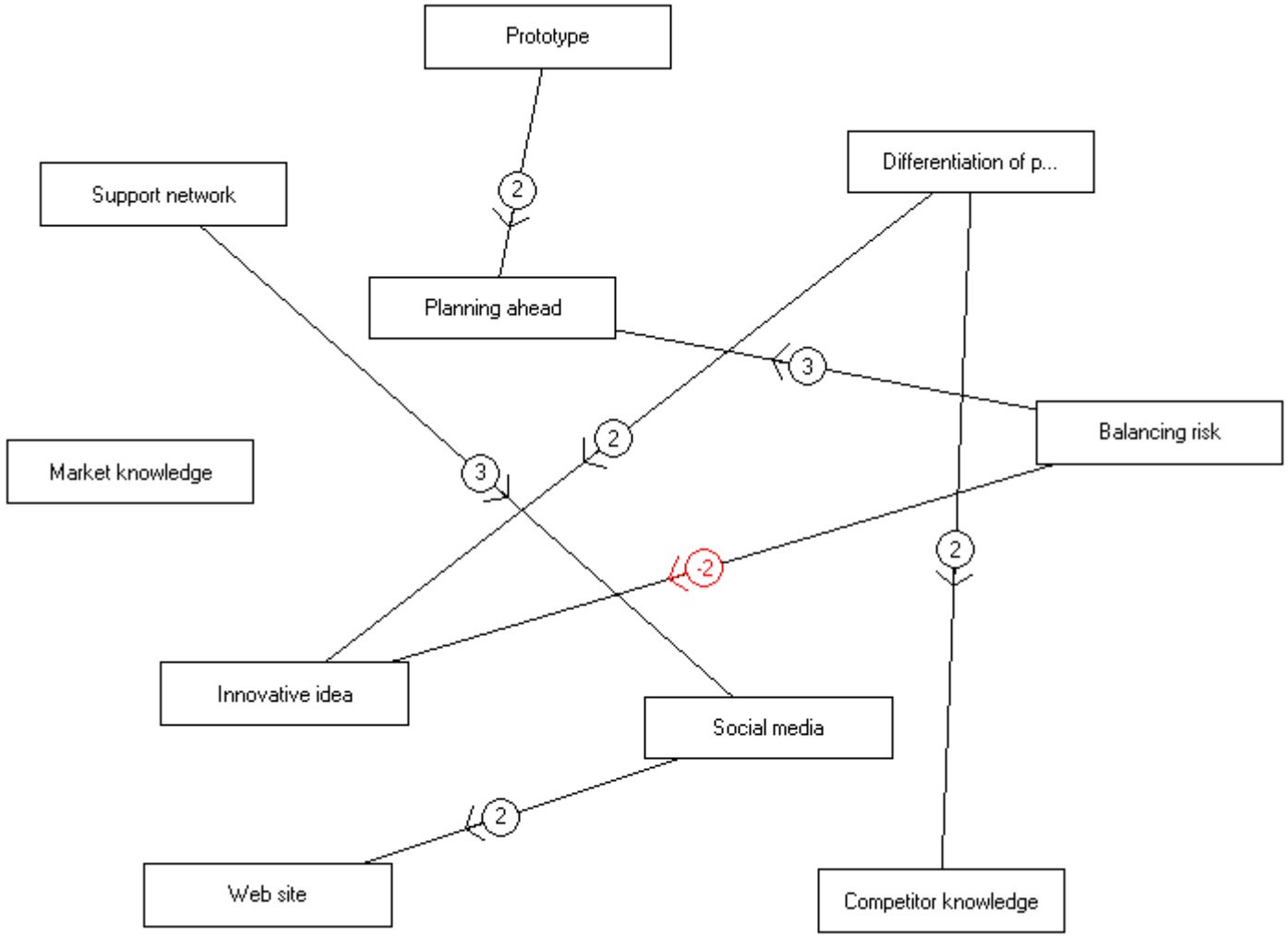

Market knowledge
2
Develop a strong team
Social media
Design
1
Motivation of staff
3
Solving a customer problem
Support network
3
User experience
3
Feedback from consumers
Cash Flow

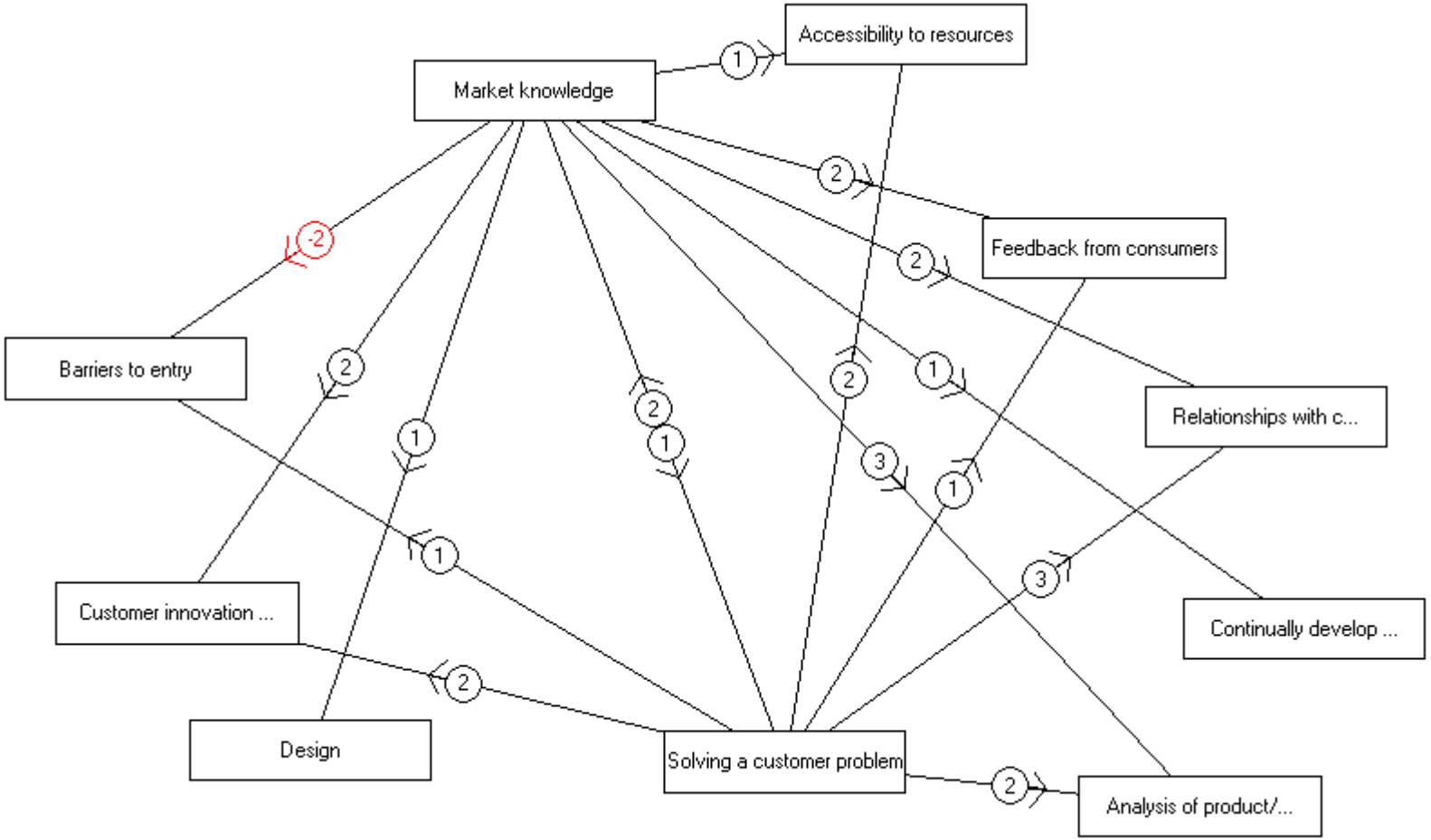

Market knowledge
2
Develop a strong team
Social media
Design
1
Motivation of staff
3
Solving a customer problem
Support network
3
User experience
3
Feedback from consumers
Cash Flow

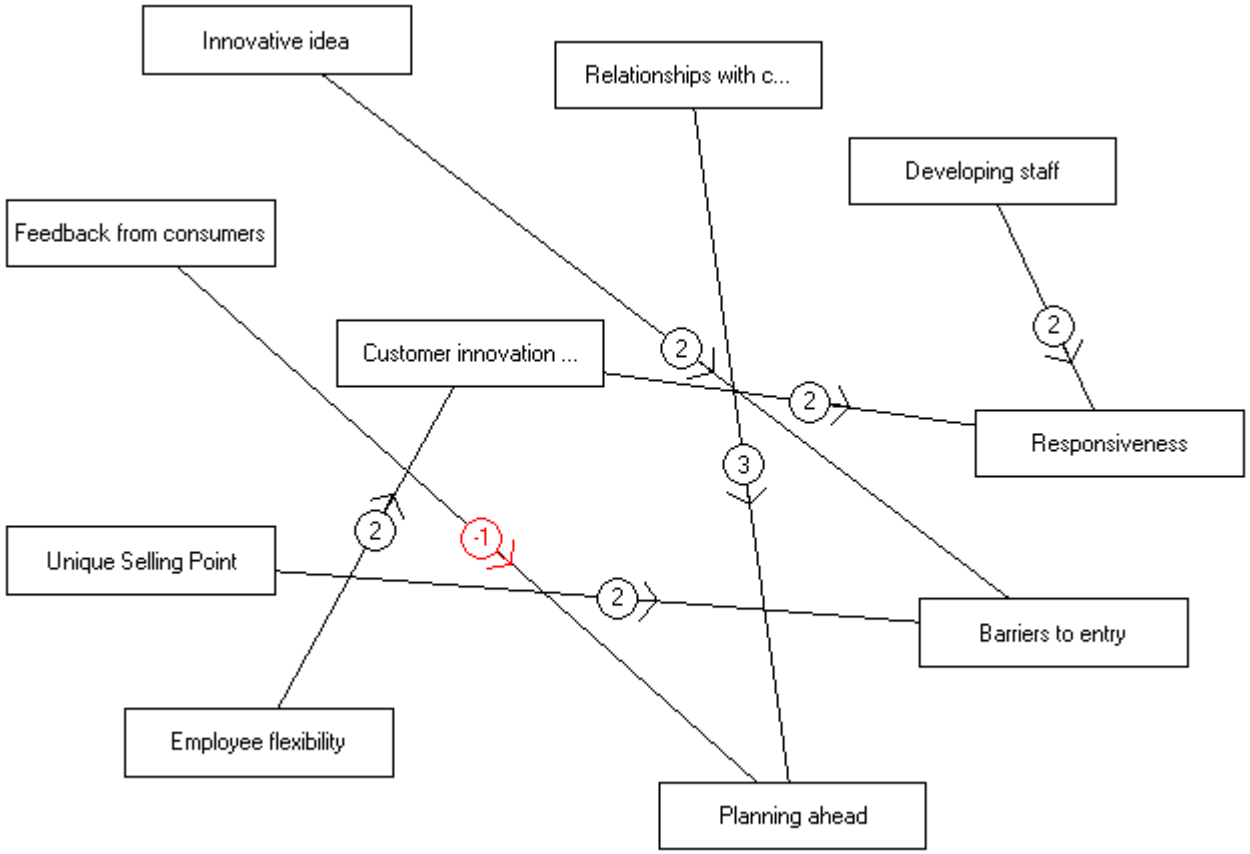

Timing of product/se...
Continually develop ...
Develop a strong team
-1
-1
-1
Cash Flow
Accessibility to resources
Unique Selling Point
1
Design
1
2
1
Solving a customer problem
3
Relationships with c...
-2
Advertising

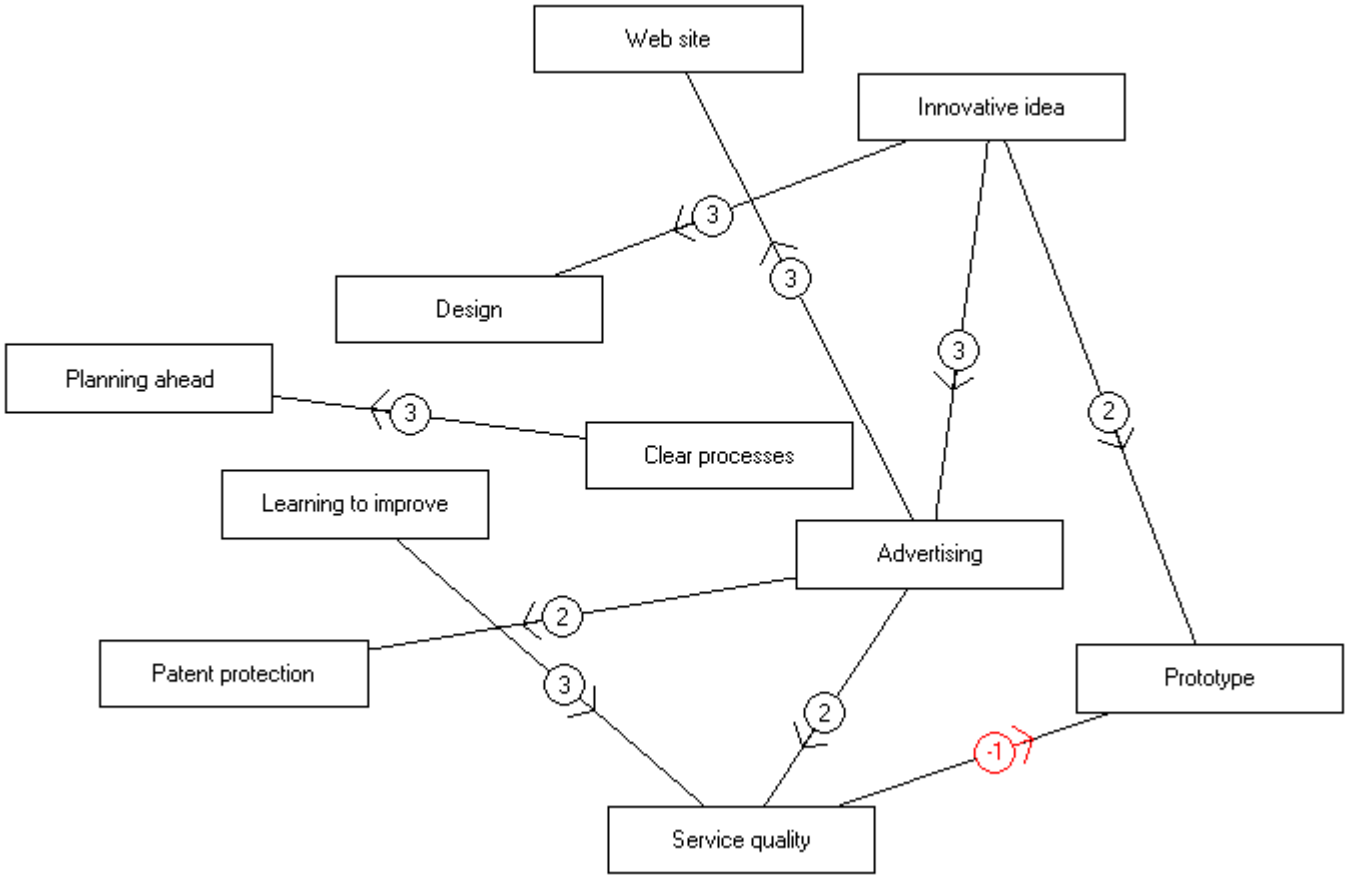

Personal motivation
1
3
Develop a strong team
2
Support network
3
2
Support from the company
Solving a customer problem
3
Market knowledge
-3
-3
1
-3
3
Price
Silo thinking
Accessibility to resources
Identify and recruit partners

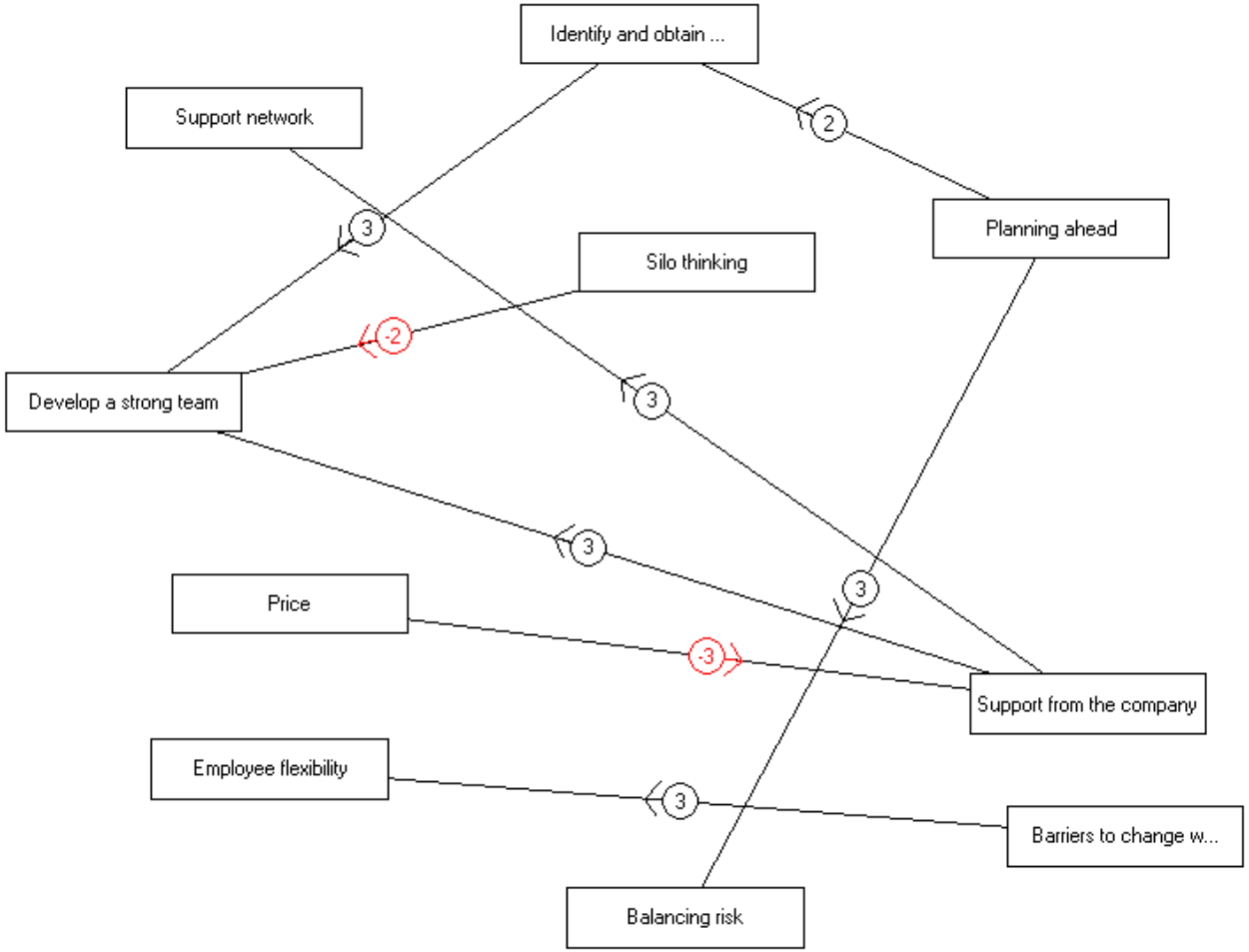

Personal motivation
Develop a strong team
Solving a customer problem
Clear processes
Innovative idea
Design
Prototype
Performance metrics
Timing of product/se...
Trial and error in d...
3
2
1
2
3
1
3
1
3
2
-2

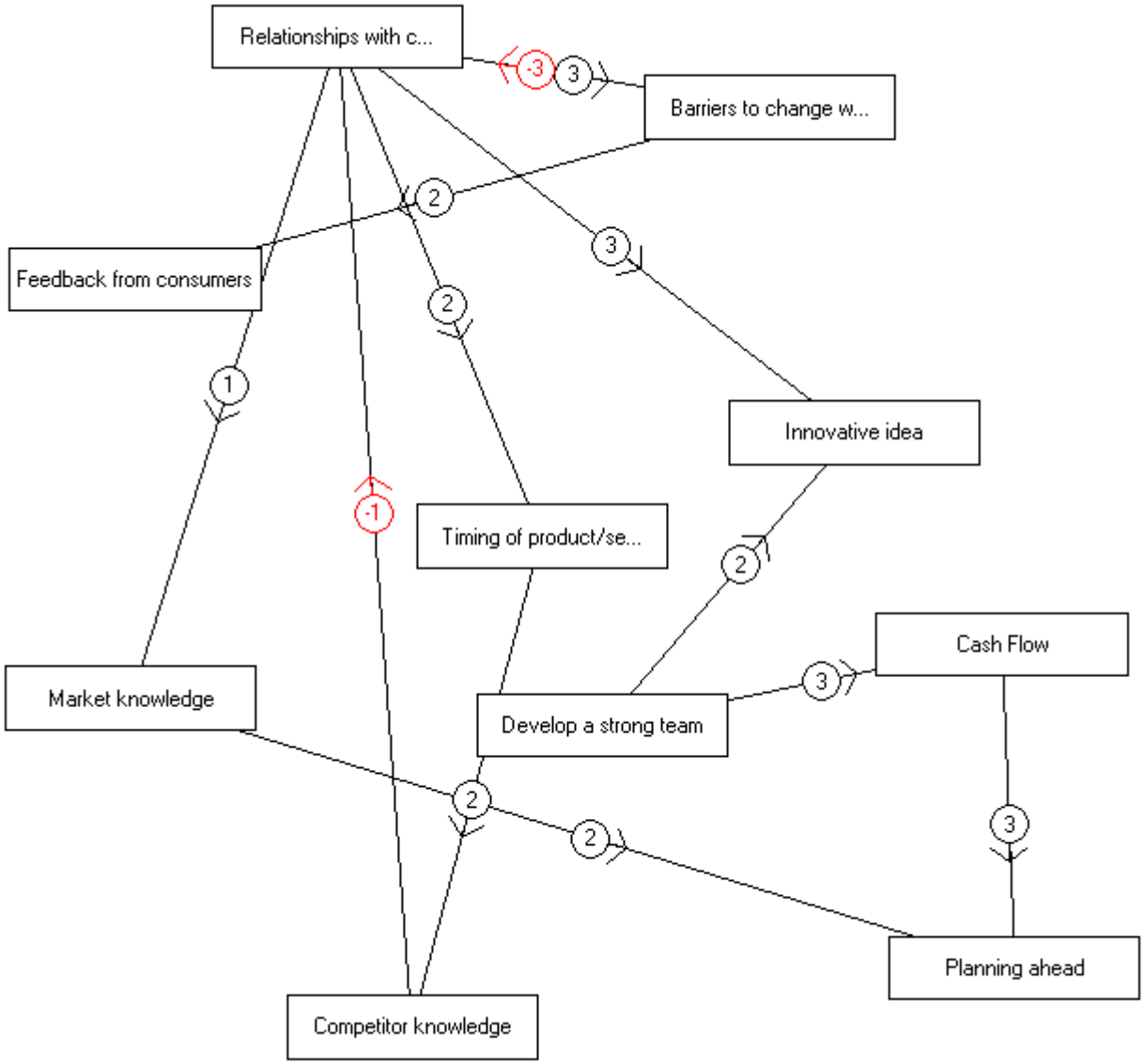

Prototype
Support network
Differentiation of p...
2
Planning ahead
3
Balancing risk
Market knowledge
2
3
-2
2
Innovative idea
Social media
2
Web site
Competitor knowledge

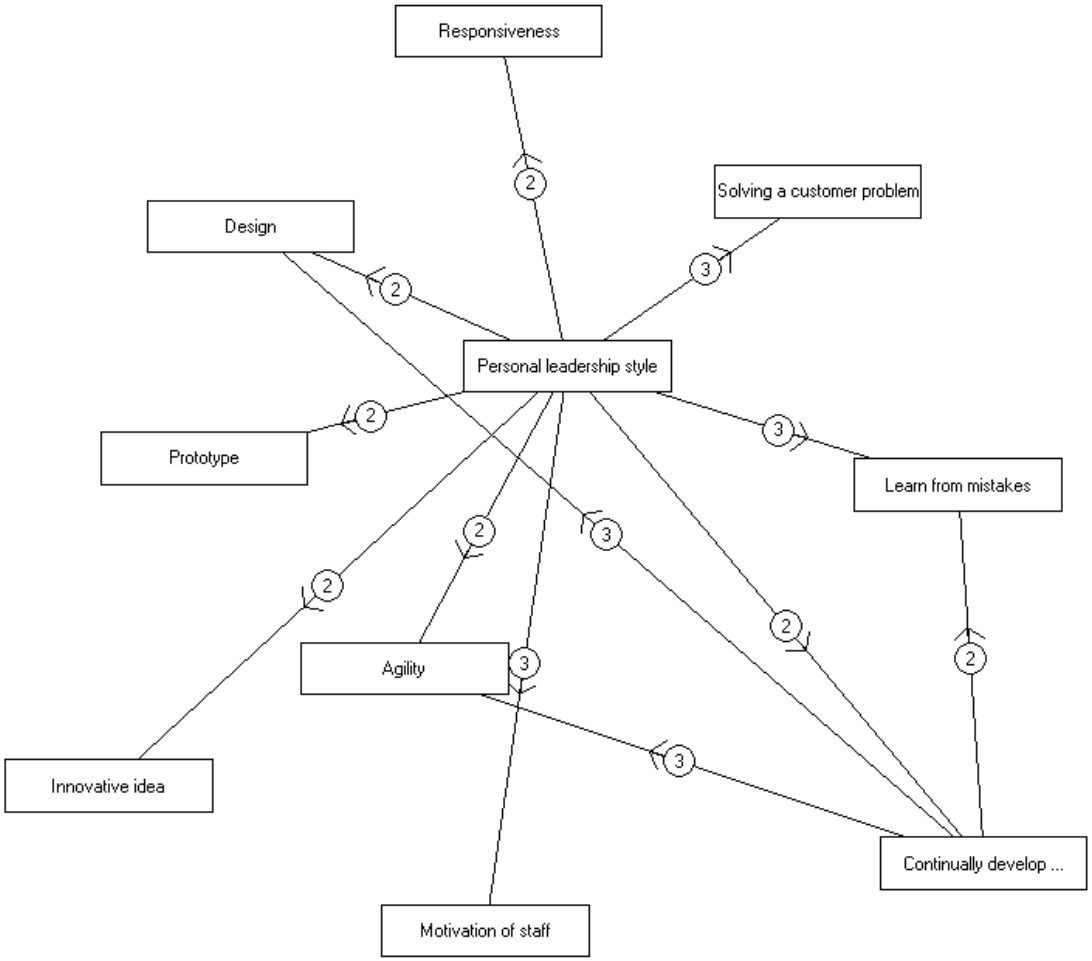

Accessibility to resources
Market knowledge
Feedback from consumers
Barriers to entry
Relationships with c...
Customer innovation ...
Continually develop ...
Design
Solving a customer problem
Analysis of product/...

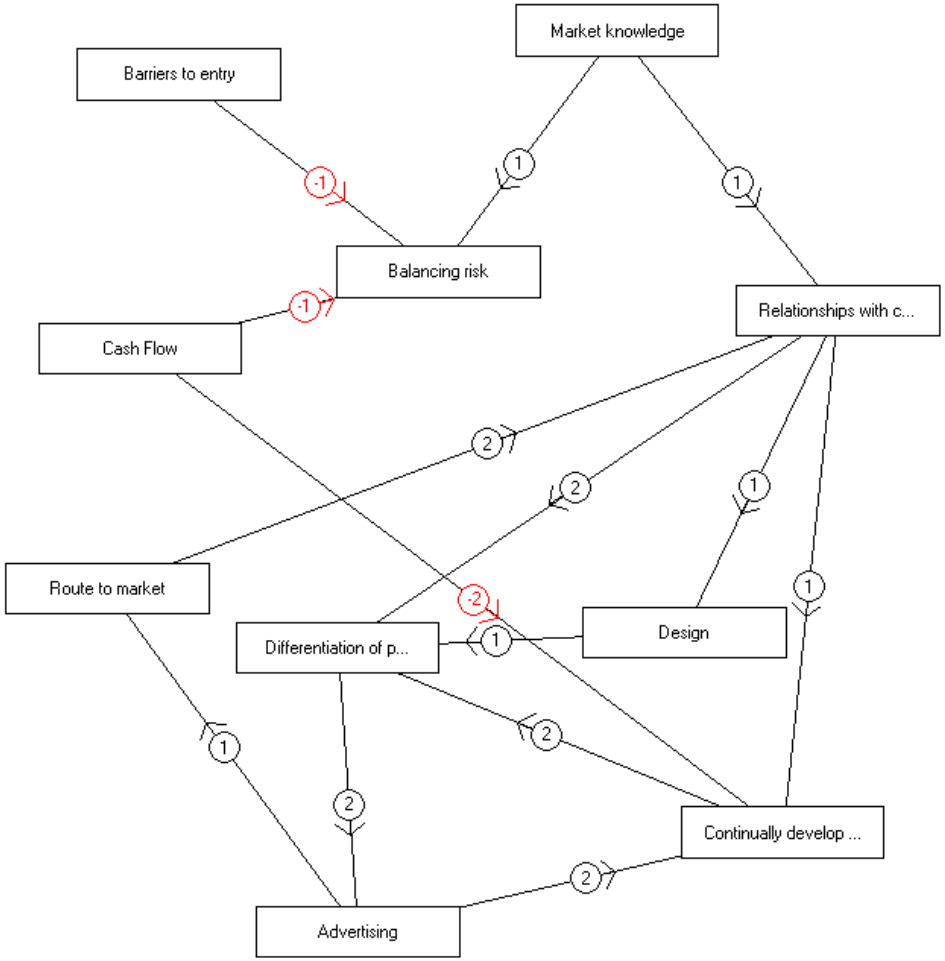

Innovative idea
Relationships with c...
Developing staff
Feedback from consumers
Customer innovation ...
Responsiveness
Unique Selling Point
Barriers to entry
Employee flexibility
Planning ahead
2
2
2
2
3
2
-1

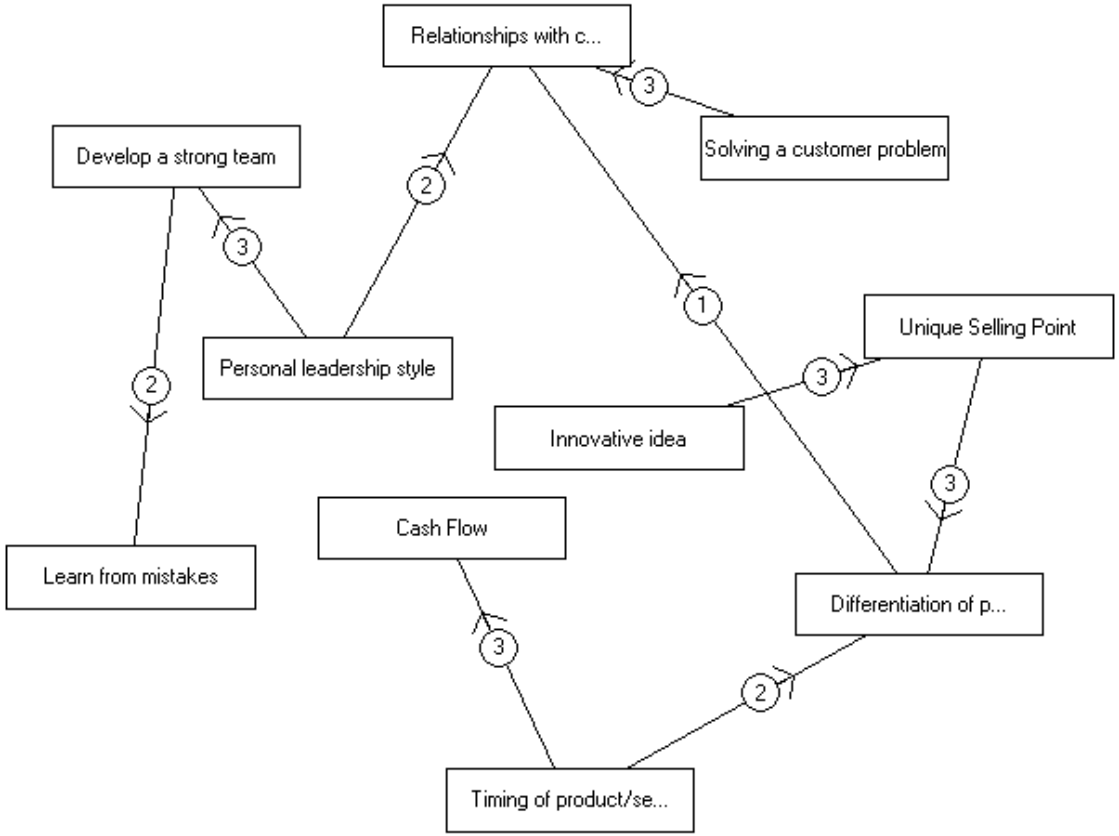

Web site
Innovative idea
3
3
Design
3
2
Planning ahead
3
Clear processes
Learning to improve
Advertising
2
Patent protection
3
2
Prototype
-1
Service quality

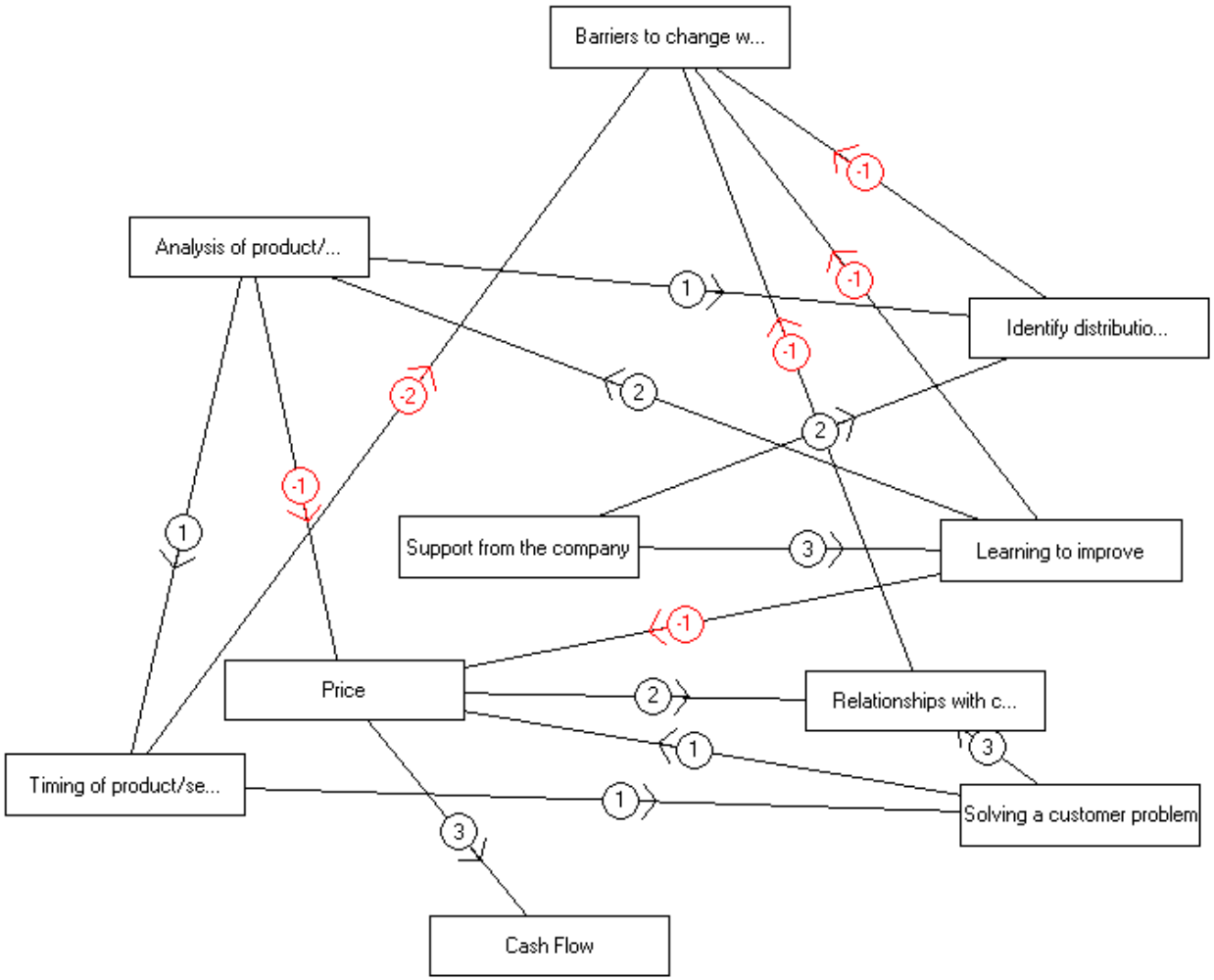

Identify and obtain ...
Support network
2
3
Planning ahead
Silo thinking
-2
Develop a strong team
3
3
3
Price
-3
Support from the company
Employee flexibility
3
Barriers to change w...
Balancing risk

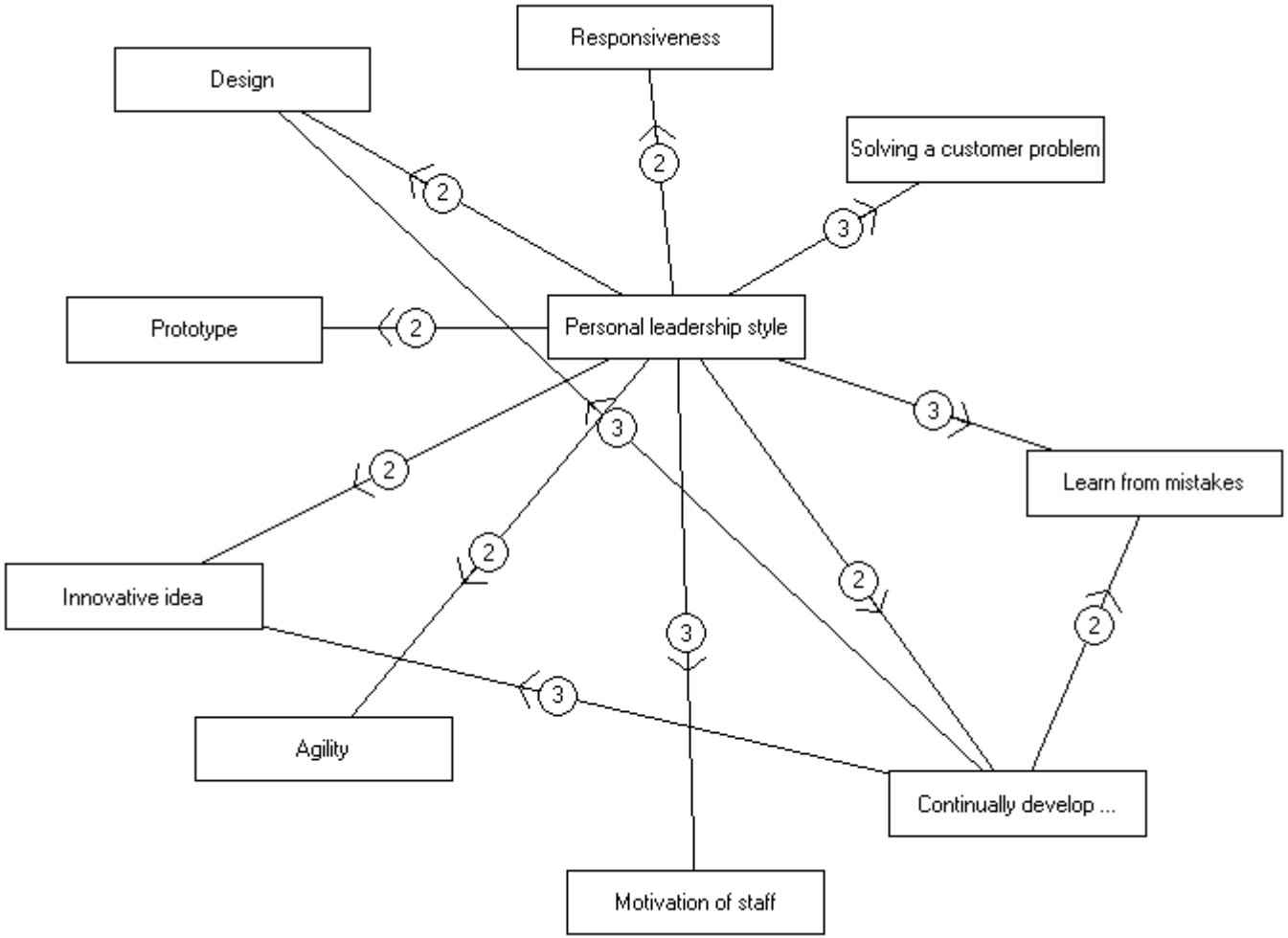

Relationships with c...
-3
3
Barriers to change w...
2
Feedback from consumers
3
2
1
Innovative idea
-1
Timing of product/se...
2
Cash Flow
3
Market knowledge
Develop a strong team
2
2
3
Planning ahead
Competitor knowledge

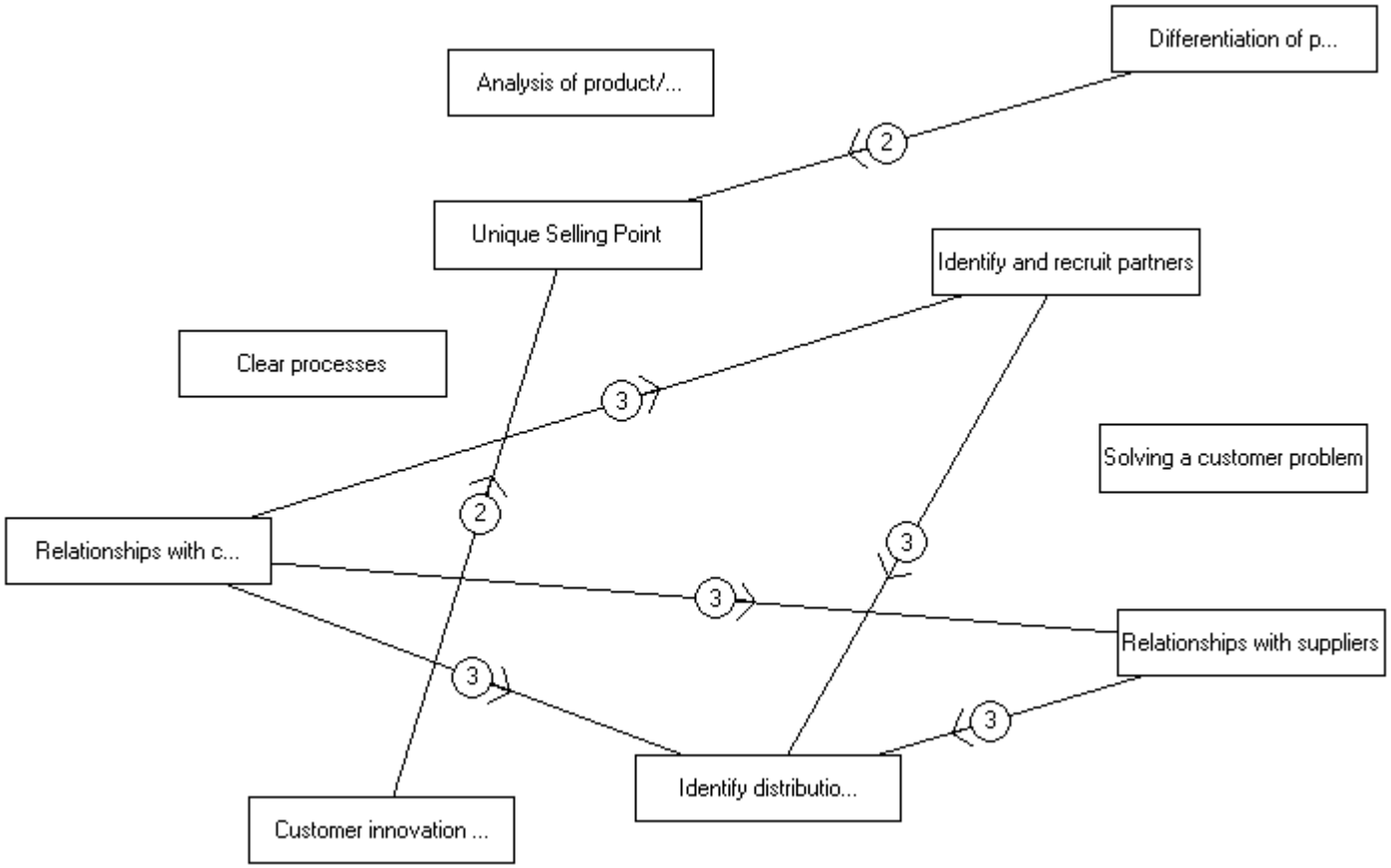

Responsiveness
Solving a customer problem
Design
Personal leadership style
Prototype
Learn from mistakes
Agility
Innovative idea
Continually develop ...
Motivation of staff

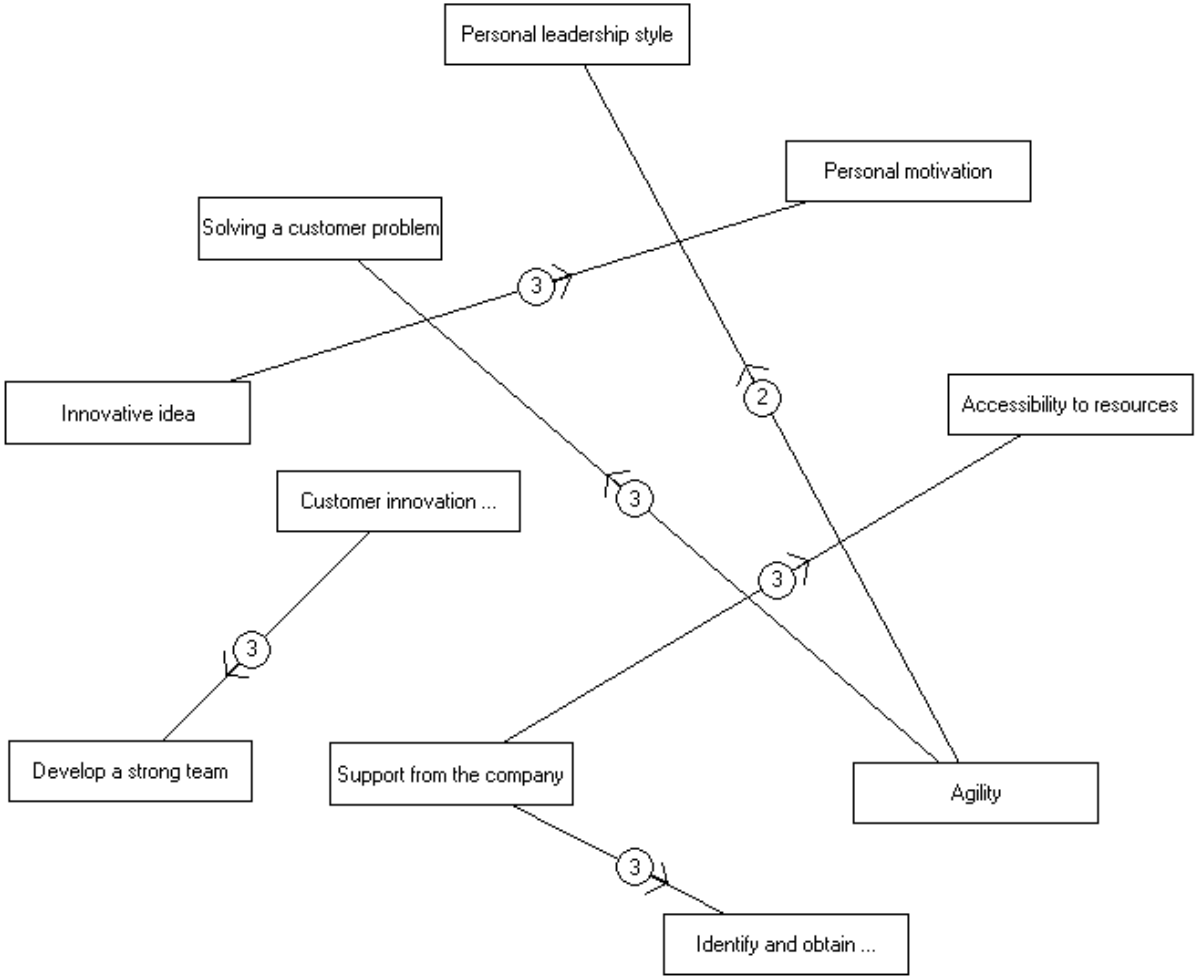

Market knowledge
Barriers to entry
Balancing risk
Relationships with c...
Cash Flow
Route to market
Differentiation of p...
Design
Continually develop ...
Advertising

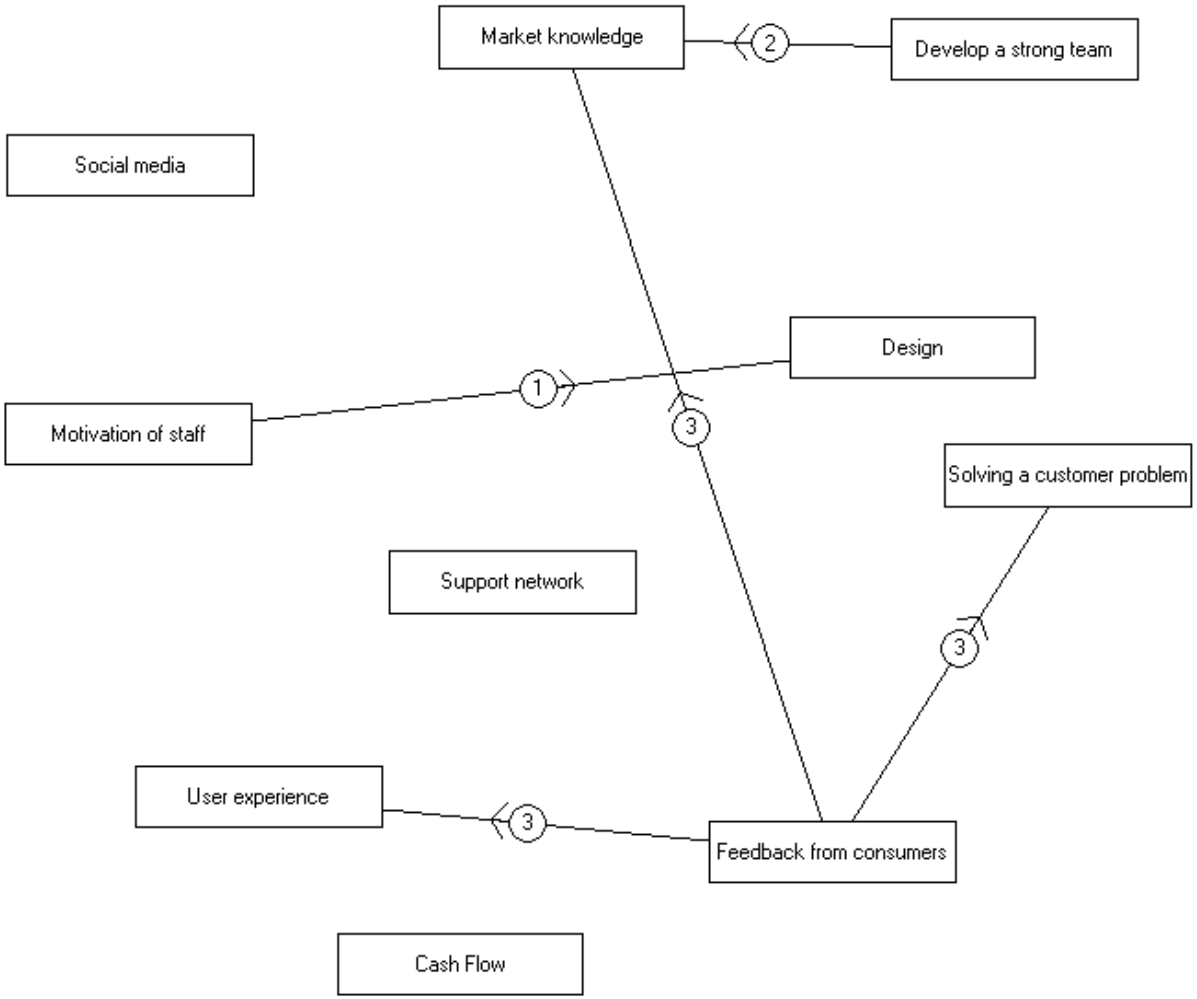

Relationships with c...
3
Solving a customer problem
Develop a strong team
2
3
Personal leadership style
1
Unique Selling Point
2
3
Innovative idea
3
Cash Flow
Learn from mistakes
Differentiation of p...
3
2
Timing of product/se...

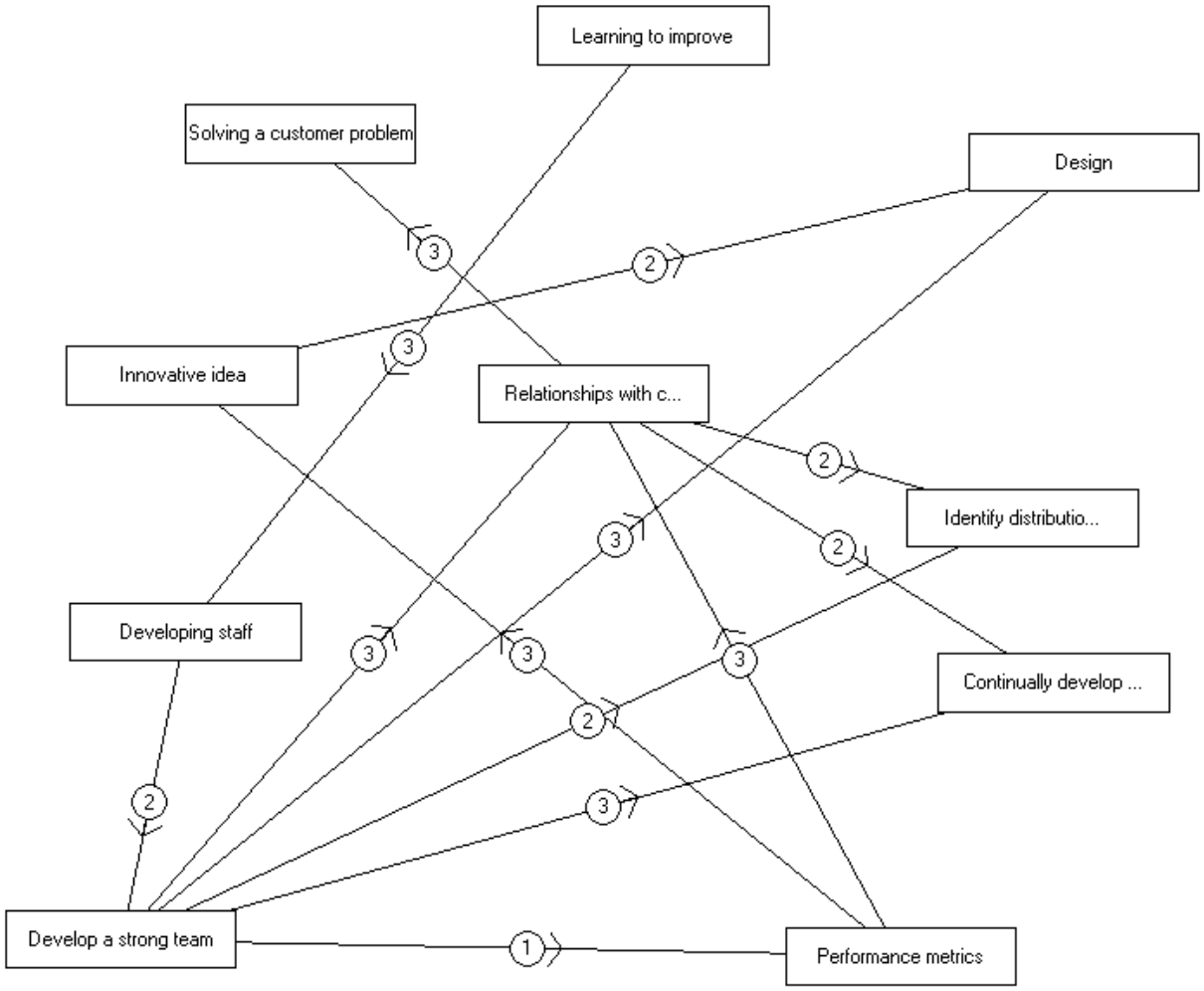

Barriers to change w...
Analysis of product/...
Identify distributio...
Support from the company
Learning to improve
Price
Relationships with c...
Timing of product/se...
Solving a customer problem
Cash Flow

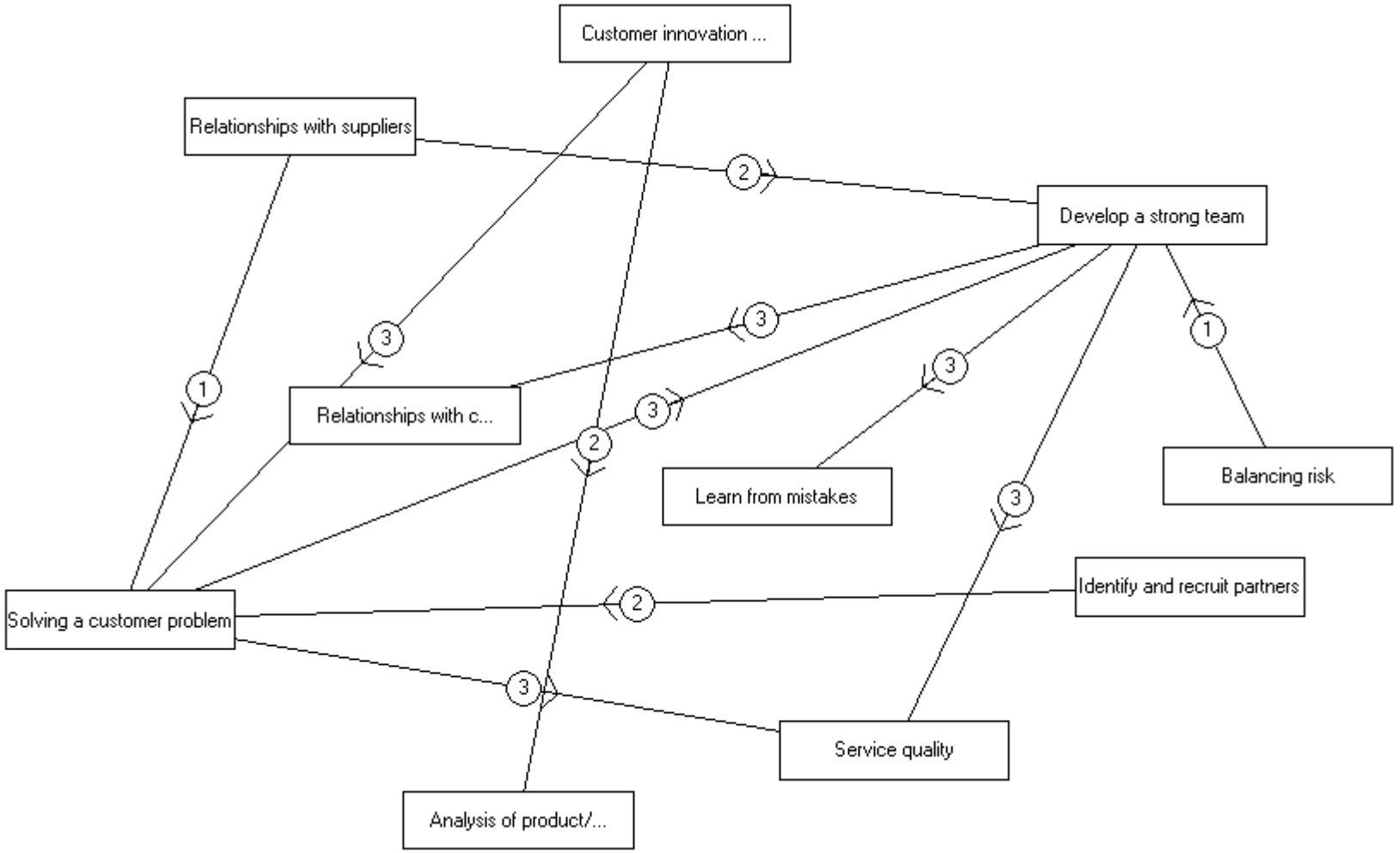

Responsiveness
Design
Solving a customer problem
Prototype
Personal leadership style
Learn from mistakes
Innovative idea
Agility
Continually develop ...
Motivation of staff

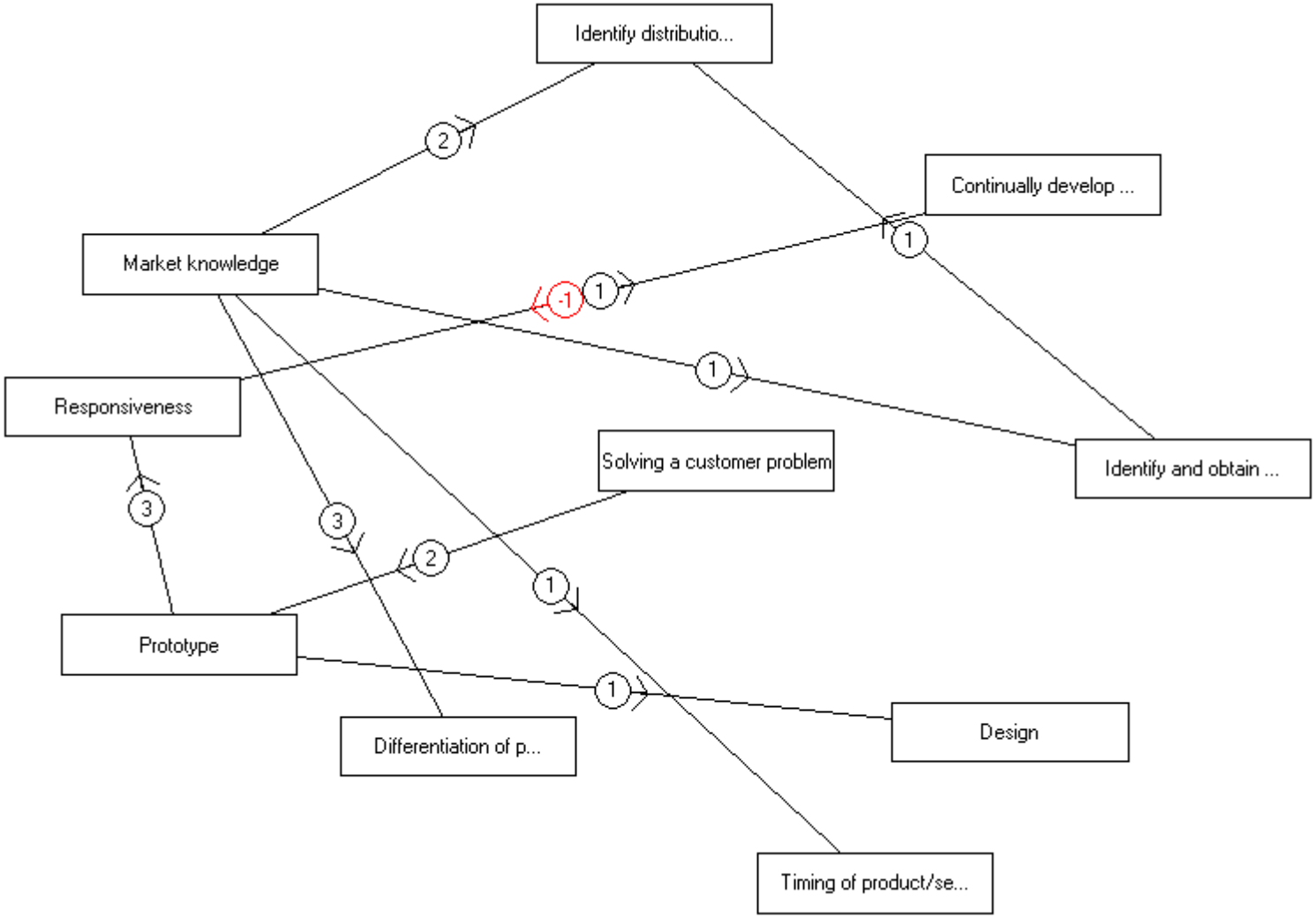

Differentiation of p...
Analysis of product/...
2
Unique Selling Point
Identify and recruit partners
Clear processes
3
Solving a customer problem
2
3
Relationships with c...
3
Relationships with suppliers
3
3
Identify distributio...
Customer innovation ...

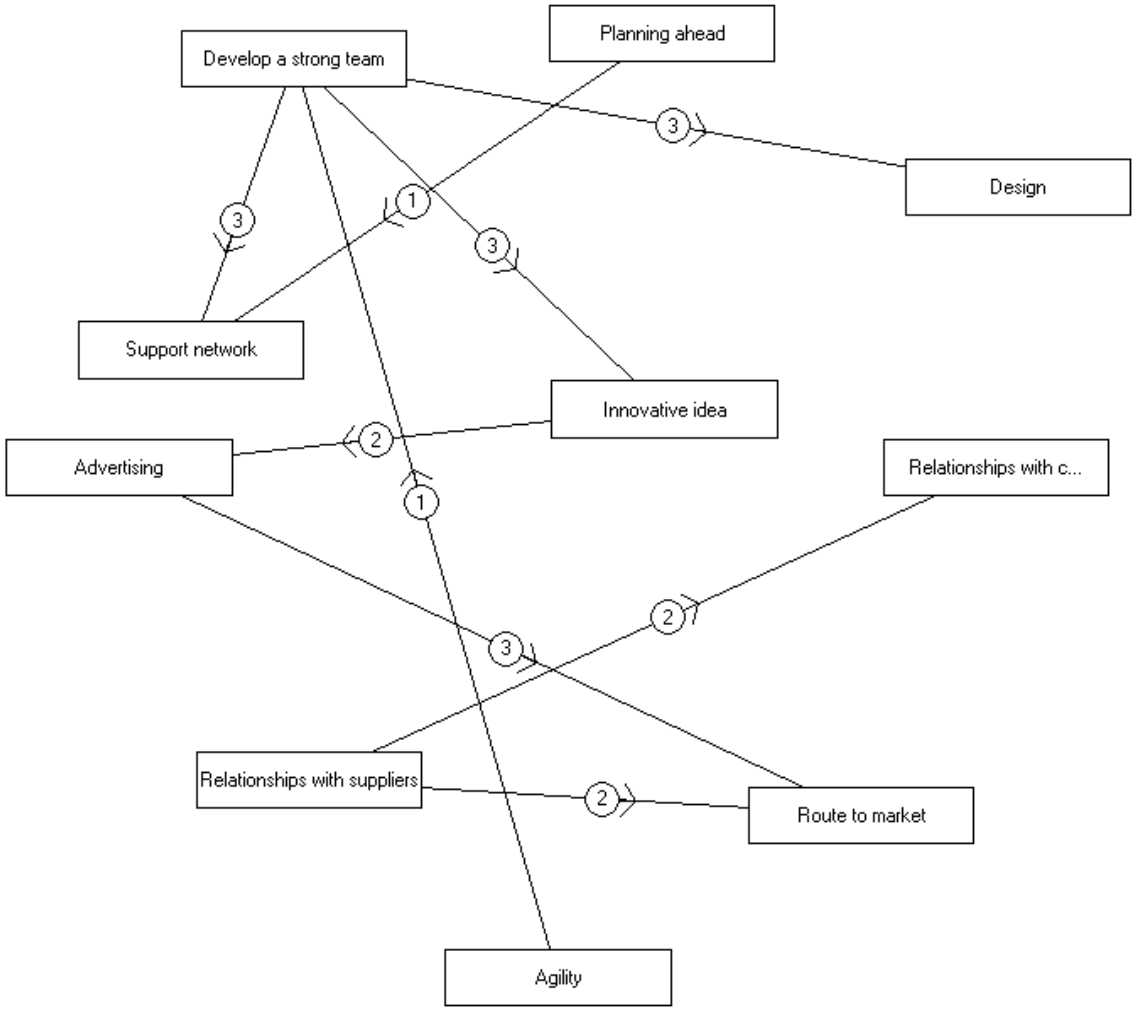

Personal leadership style
Personal motivation
Solving a customer problem
3
Innovative idea
2
Accessibility to resources
Customer innovation ...
3
3
3
Develop a strong team
Support from the company
Agility
3
Identify and obtain ...


Market knowledge
2
Develop a strong team
Social media
Design
1
Motivation of staff
3
Solving a customer problem
Support network
3
User experience
3
Feedback from consumers
Cash Flow


Learning to improve
Solving a customer problem
Design
Innovative idea
Relationships with c...
Identify distributio...
Developing staff
Continually develop ...
Develop a strong team
Performance metrics


Customer innovation ...
Relationships with suppliers
Develop a strong team
Relationships with c...
Learn from mistakes
Balancing risk
Identify and recruit partners
Solving a customer problem
Service quality
Analysis of product/...


Identify distributio...
Continually develop ...
Market knowledge
Responsiveness
Solving a customer problem
Identify and obtain ...
Prototype
Differentiation of p...
Design
Timing of product/se...
2
1
1
-1
1
3
3
2
1
1


Develop a strong team
Planning ahead
Design
Support network
Innovative idea
Advertising
Relationships with c...
Relationships with suppliers
Route to market
Agility
3
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3
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2
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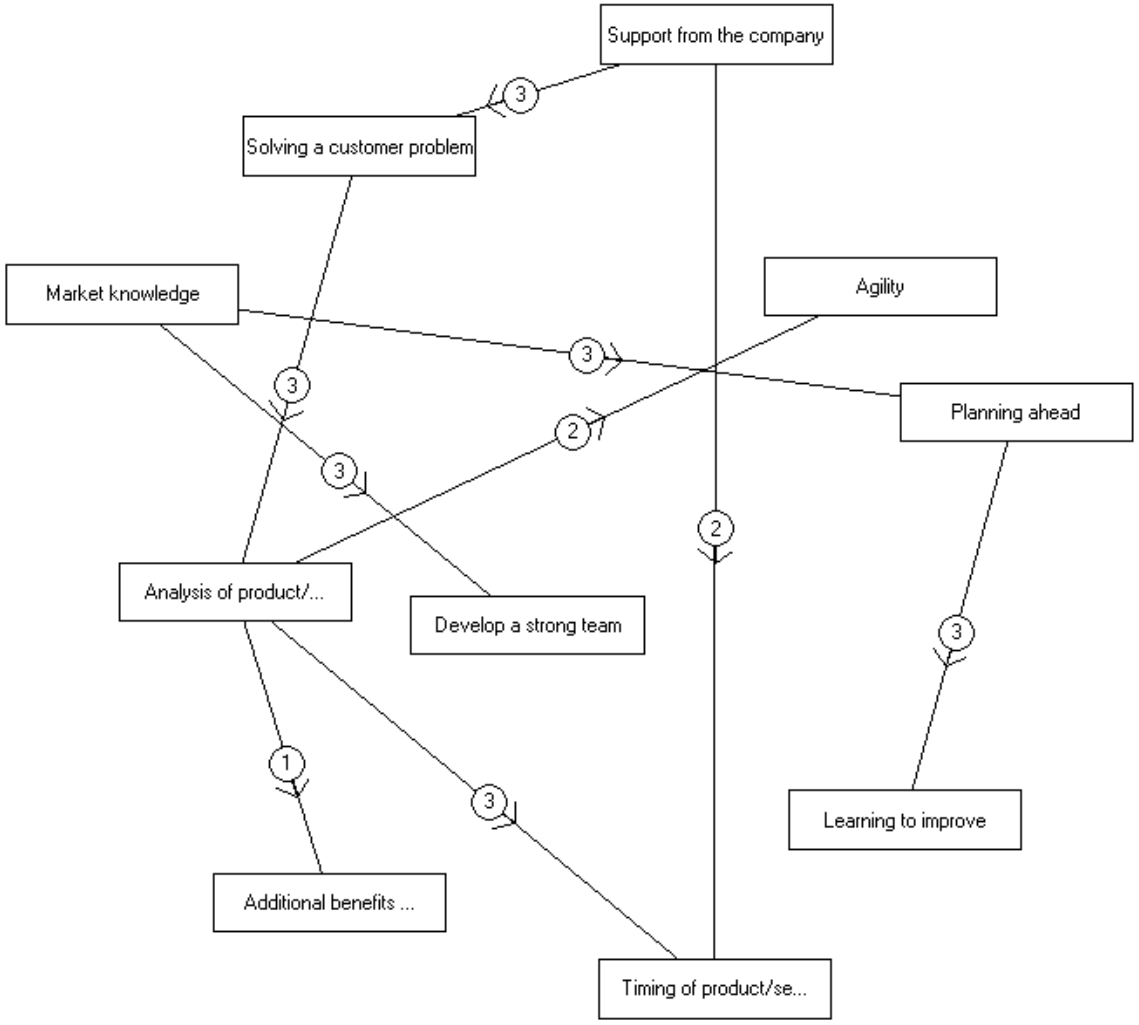
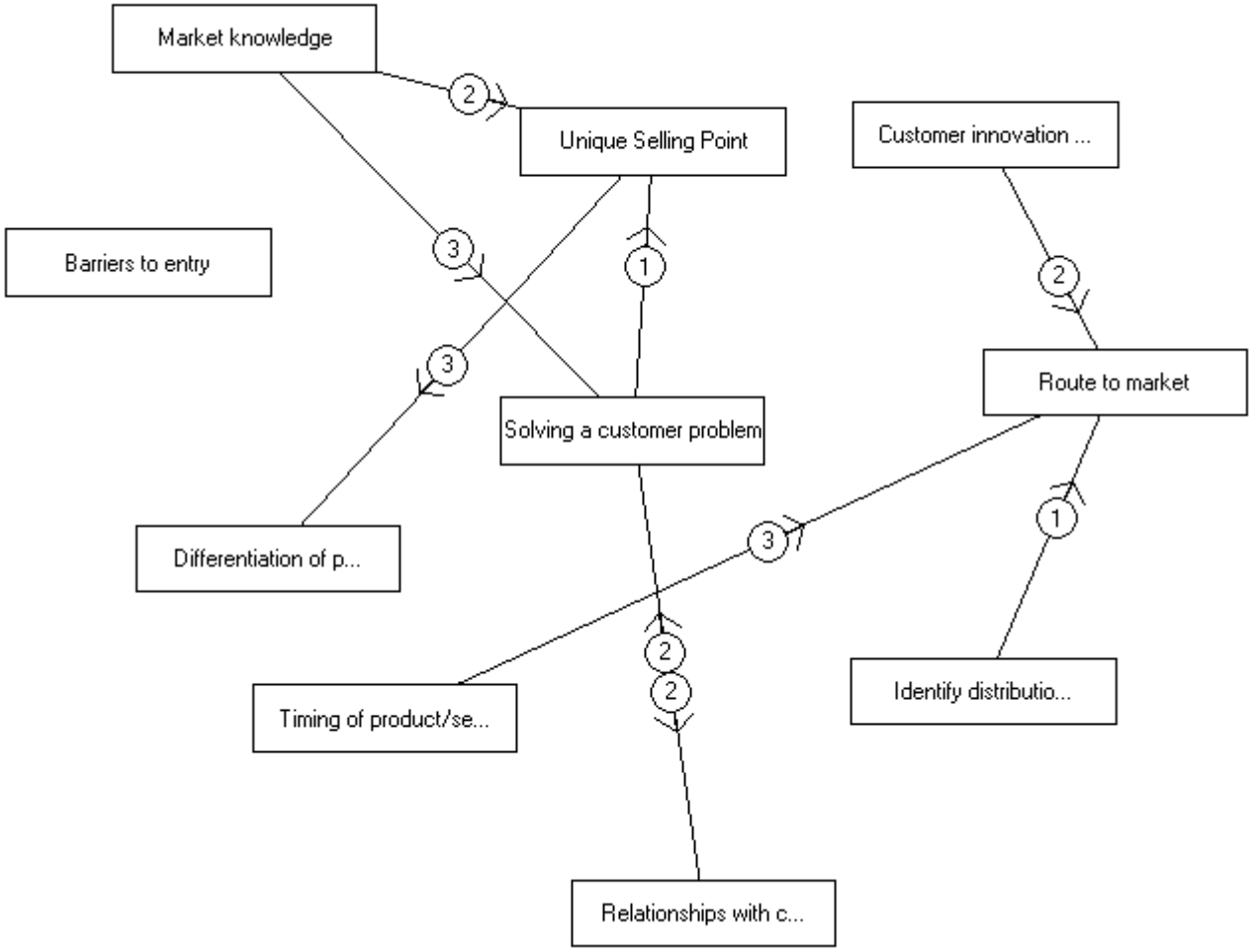
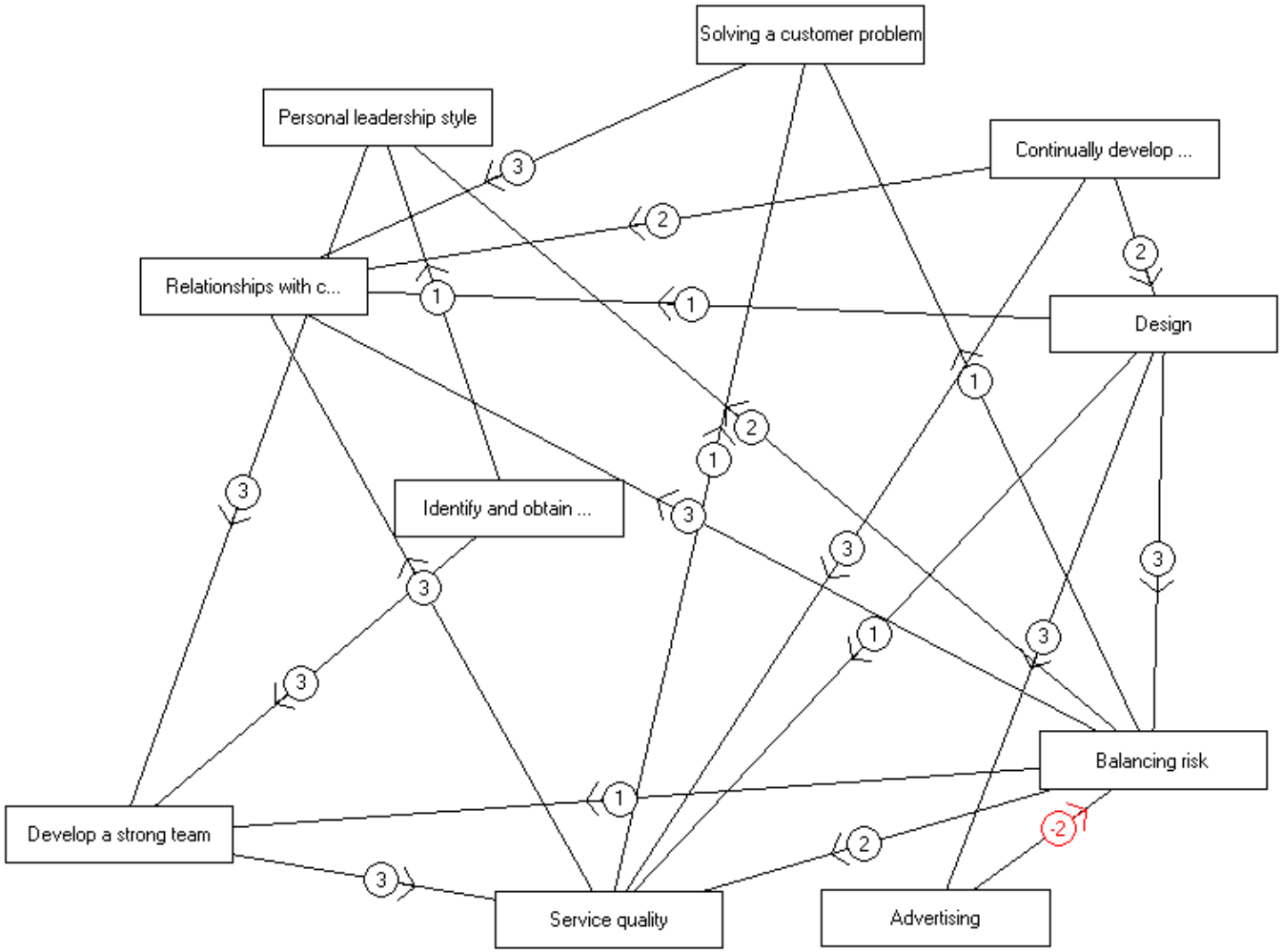
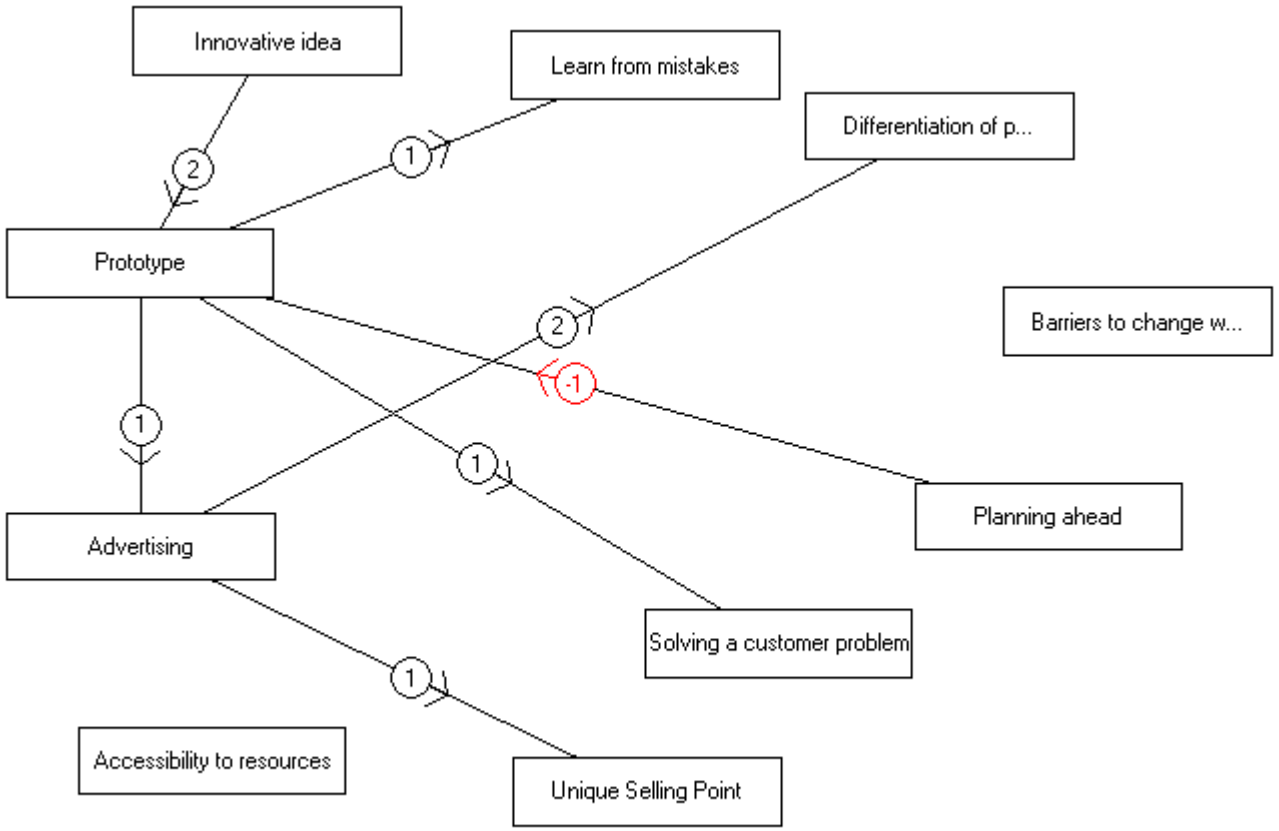
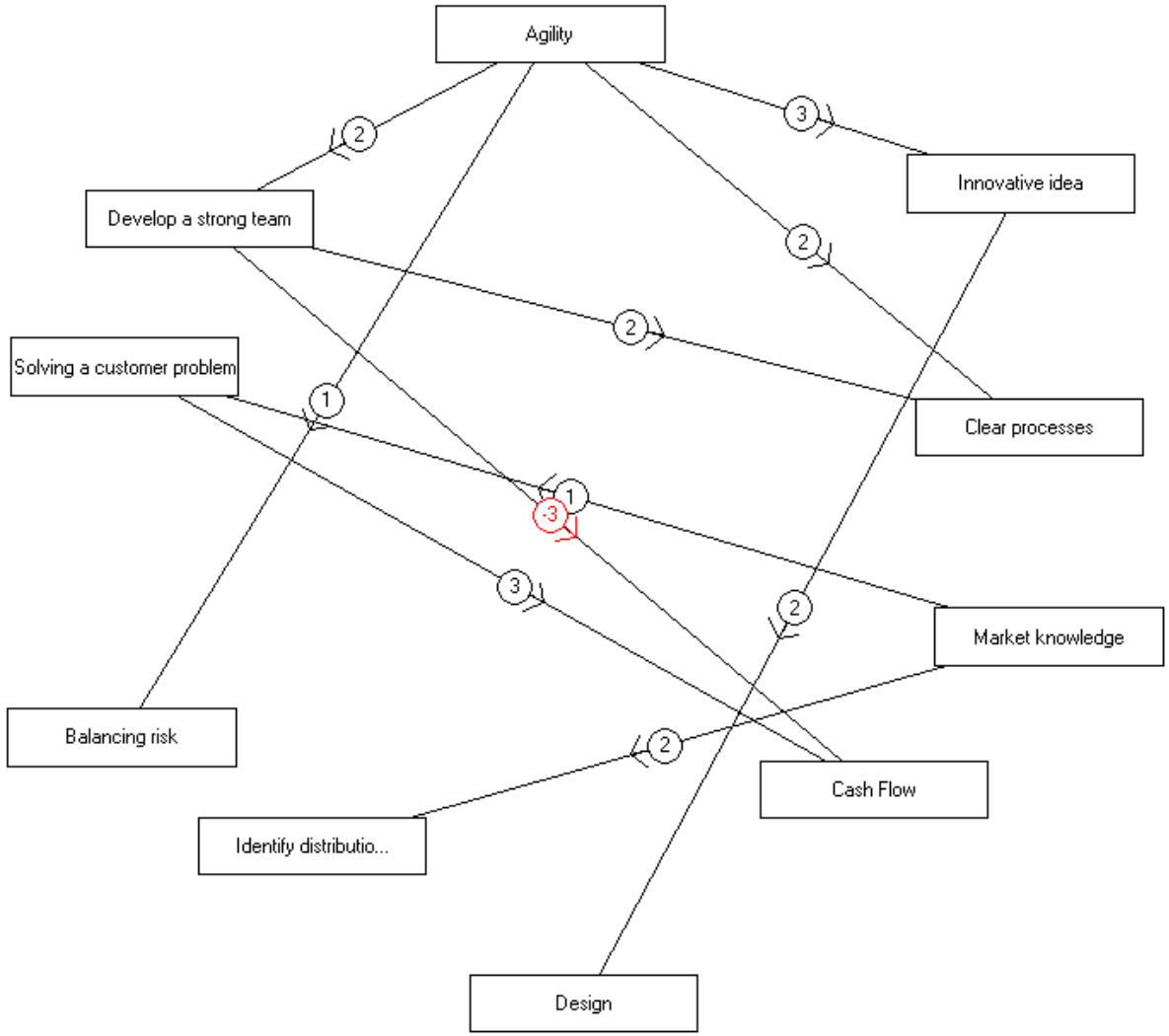
3
2
2

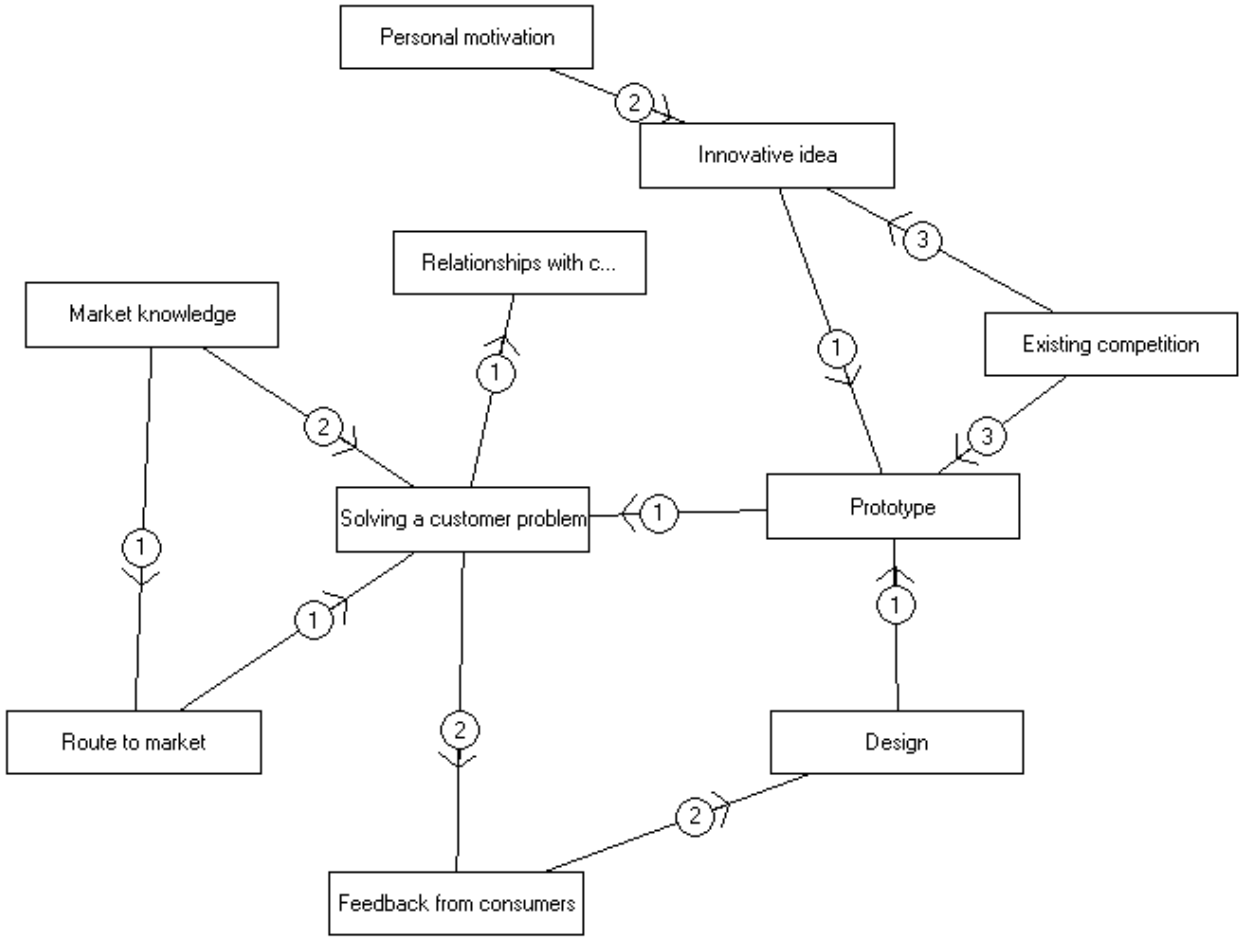

Support from the company
3
Solving a customer problem
Market knowledge
Agility
3
3
Planning ahead
2
3
2
Analysis of product/...
Develop a strong team
3
1
3
Learning to improve
Additional benefits ...
Timing of product/se...

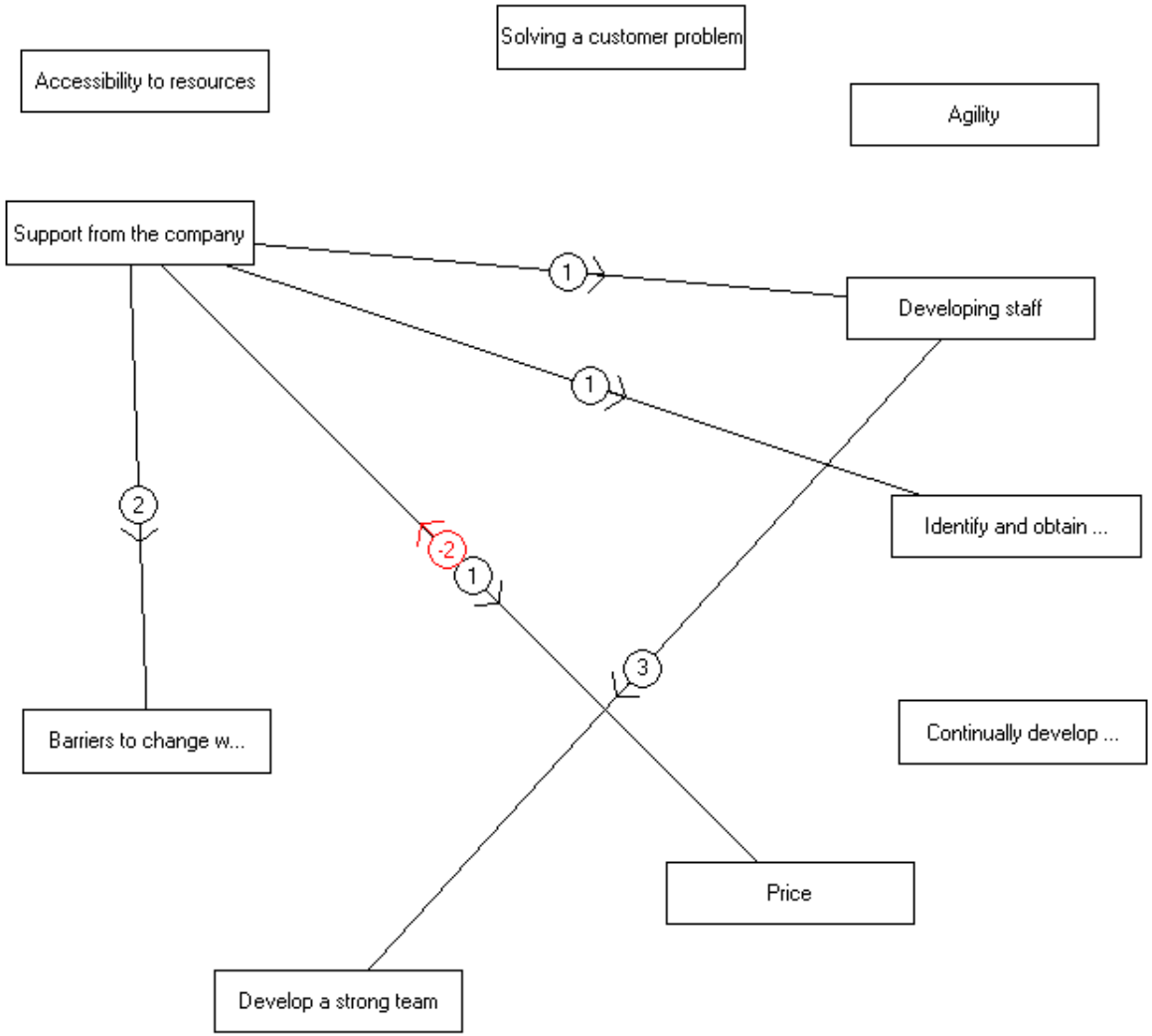

Market knowledge
Unique Selling Point
Customer innovation ...
Barriers to entry
Route to market
Solving a customer problem
Differentiation of p...
Timing of product/se...
Identify distributio...
Relationships with c...


Solving a customer problem
Personal leadership style
Continually develop ...
Relationships with c...
Design
Identify and obtain ...
Balancing risk
Develop a strong team
Service quality
Advertising


Innovative idea
Learn from mistakes
Differentiation of p...
2
1
Prototype
Barriers to change w...
2
-1
1
1
Planning ahead
Advertising
Solving a customer problem
1
Accessibility to resources
Unique Selling Point


Agility
Innovative idea
Develop a strong team
Solving a customer problem
Clear processes
Market knowledge
Balancing risk
Cash Flow
Identify distributio...
Design


Personal motivation
Innovative idea
Relationships with c...
Market knowledge
Existing competition
Solving a customer problem
Prototype
Route to market
Design
Feedback from consumers


Solving a customer problem
Accessibility to resources
Agility
Support from the company
1
Developing staff
1
2
-2
1
Identify and obtain ...
3
Barriers to change w...
Continually develop ...
Price
Develop a strong team