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Diffusion of high technology product in industrial markets and the role of network effects. A case study of VR/XR product in the B2B markets.

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Teknologian kehitys, kasvava digitalisaatio sekä yritysten keskinäisriippuvuus eri sidosryhmien välillä kiihdyttävät yhteistyön sekä kommunikaation tarvetta. Yritykset luovat arvoa yhä enemmän yhdessä etenkin teknologiamarkkinoilla, joilla laitteiden sekä ohjelmistojen yhteensopivuus on kriittinen tekijä. Tämän tutkimuksen on tarkoitus selvittää kuinka teknologiatuotteen 'verkostovaikutus' tai 'verkostoulkoisvaikutukset' vaikuttavat uuden innovaation leviämiseen kasvavilla virtuaaliteknologian yritysmarkkinoilla innovatiivisten organisaatioiden keskuudessa. Taloustieteessä verkostovaikutus tarkoittaa tilannetta, jossa hyödykkeen kulutuksesta saatava hyöty riippuu sen käyttäjien lukumäärästä. Verkostovaikutuksen hyöty perustuu 'suoraan' tai 'epäsuoraan' arvoon. Suora hyöty riippuu käyttäjien lukumäärästä ja epäsuora laitteen yhteensopivuudesta eri ohjelmistojen kanssa. Ilmiön vaikutuksia yritysmarkkinoilla laitteen leviämiseen vaikuttavana tekijänä on tutkittu vähän. Aikaisempi tutkimus osoittaa, että teknologian verkostovaikutusominaisuus voi vaikuttaa olennaisesti uuden innovaation menestykseen markkinoilla. Tämä kvalitatiivinen tapaustutkimus hyödyntää abduktiivista analyysimenetelmää ja tutkii yrityksille suunnatun virtuaaliteknologiatuotteen mahdollisia verkostovaikutusominaisuuksia sekä niiden vaikutusta teknologian leviämiseen kohderyhmissä. Tutkimus osoittaa, että organisaatioiden ostopäätöksiä ohjaa ensisijaisesti tuotteen hyöty, eli sen synnyttämä arvo sille osoitetussa prosessissa. Toinen teknologiatuotteiden käyttöönottamista määrittävä tekijä on laitteen yhteensopivuus organisaation nykyisten ohjelmistojen sekä työprosessien kanssa. Tutkimuksen mukaan organisaatiot odottavat kuitenkin tulevaisuudessa enemmän 'suoria' hyötyjä teknologian yleistyessä, etenkin yhteistyön lisäämiseksi organisaation sisäisesti eri yksiköiden välillä. Tulokset osoittavat, että laitteen arvon määrittää lopulta saatavilla olevien ohjelmistojen lukumäärä sekä monipuolisuus yritysympäristössä.

ABSTRACT

Author:	Olli Tiainen
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The development of technologies and interdependency between hardware/software systems are creating coordination issues when firms introduce new innovations to markets. Increasingly the value is created in collaboration with different industry partners. This interrelation between firms is especially typical in hardware/software markets. Thus, this research links the role of network effects in new high technology product diffusion among first users in the B2B markets. A nascent immersive technology industry exposes the potential adopters to many uncertainties and product-related risks. Hence, sufficient coordination with network partners and educating early adopters in the early product lifecycle phase is essential. Previous studies regarding network effects and its role in industrial diffusion are insufficient. The value of the network effect product derives from two different sources: the eventual user base of the product (direct) and the supply of complementary products and services for the focal product (indirect). In this study, the abductive research approach is adopted to enable constant reflection between theories and empirical data. A qualitative case study was selected to analyze the interpretations of network effects among the respondents. The results indicate that organizations' primary factor in purchase decisions is the intrinsic product value and novelty of the innovation. Further, system compatibility and available software applications were also critical factors in product trials. In the future, as the technology and industry mature, organizations are expecting more 'direct' benefits to enhance the intraorganizational collaboration and creativity in multiuser scenarios.

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Where to start? What a journey this was.

So many unforgettable memories that telling them would take the additional eight years as it took to finish my degree in the prestigious place called LUT University.

I remember the time when I got the approval letter form LUT. The amount of joy was mixed with slight disappointment. Moving from the capital to Lappeenranta wasn't part of my original plan. But as in life in general, things don't usually go like you expect them to go.

Still don't know where to start. Hey, I remember when I arrived at Lappeenranta for the first time as a fresh economics student. My friend loaned me the money for the train ticket, and two of my good friends were kind enough to offer me shelter for the first two weeks of my LUT journey.

Besides the valuable degree, I managed to get to know people who I can call today my life-long friends.

It took 7 plus years to cross the finish line, but I would not trade those years for anything. As Oscar Wilde said: "Nowadays the people know the price of everything and the value of nothing."

Thank you, Jussi, for opening the curtain to a fascinating world. I truly appreciate this opportunity. Hopefully, this thesis can offer you even one idea or insight that you can further harness. Then I feel that I succeeded. And thank you, Timo, Markus, Miika, Casper, and Daniel, for sharing your precious time and insights!

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Olli Tiainen

Helsinki,

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1 INTRODUCTION

The increasing digitalization and advancement in technologies in the global economy are transforming many industries into markets that exhibit network effects (Lee and O'Connor, 2003; Shocker, Bayus, and Kim, 2004). This change is driven by the rapid technological progress within different domains and especially technology and knowledge-intensive fields can seize the opportunity (Podoynitsyna, Song, van der Bij and Weggeman, 2013). Hence, recent studies (Goldenberg, Libai and Muller, 2010; Srinivasan, Lilien, and Rangaswamy, 2004) indicates that the extrinsic value sources of network effect product are present in a variety of industries and markets depending on the product category. These extrinsic value sources are called *direct* and *indirec*t network effect.

So far, the majority of the research has focused on the network effects in consumer markets and goods. Thus, little research exists on the relationship between diffusion of high-technology industrial products and network effects. The role of direct (installed base) and indirect (compatibility/complementary products) network effects are product value sources that can have a significant impact on the current and future expectations of the product performance (Katz and Shapiro, 1994). In addition to product quality, network effects can facilitate early adoption, reduce perceived product uncertainty, and lock-in customers to gain a long-term competitive advantage for the supplying company. Hence, the objective of this study is to investigate the role of the direct and indirect product value in the industrial diffusion process.

According to (Katz and Shapiro, 1986;1992;1994; Farrell and Saloner, 1986), the factors that drive dominant design selection has focused on network externalities and its different determinants. A nascent immersive computing industry dealing with virtual reality (VR) and mixed reality (XR) technologies targeted to high-end enterprise users serve an interesting context to study the potential impacts of network externalities in the B2B context. Further, in industries where the dominant design has not yet emerged, firms face critical choices about how and when to deploy their technologies (Schilling, 2002), thus they must plan their timing of entry by the evolution of complementary technologies and customer requirements (Christensen, 1998). Current research studying the network effects in industrial markets is inadequate and thus, further research is needed.

1.1 Background

Various academics have studied NE in different markets and product categories. Historical examples of NE are Microsoft and Intel's Wintel system (Hill, 1997), telephones and fax machines (Katz and Shapiro, 1985), and computer operating systems (Podoynitsyna et al., 2013). Researchers are intrigued whether NE can lead the firm for long-term competitive position and success (Farrell and Saloner, 1986; Katz and Shapiro, 1994; Hill, 1997). Katz and Shapiro (1985) define markets with network effects as a situation where the utility of adopting the innovation grows as the eventual user base increases. Hence, the utility that a consumer derives from adopting innovation is positively affected by the number of other product users or businesses that have entered the network (Katz and Shapiro, 1985). Besides direct user externalities derived by the size of the network, there may be indirect effects that give rise to consumption externalities (Katz and Shapiro, 1985). These indirect network externalities originate when complementary products or services are pivotal in generating value for the focal product (Podoynitsyna et al., 2013). Hence, especially in the hardware and software markets, the focal hardware product needs compatible ancillary software applications to create value that Katz and Shapiro (1985) defines as the software-hardware paradigm. The third positive consumption externality derives from the service network, which is determined by the availability and quality of post-purchase service for the product (Katz and Shapiro, 1985).

The stream of studies about the critical drivers of new product performance is probably the most diverse topics in the research field, and usually, product quality is considered as one of the most crucial elements to obtain competitive advantage (Molina-Castillo, Munuera-Alemán, and Calantone, 2011; Tellis, Niraj, and Yin, 2008). Recently, a group of researchers has suggested that the role of complementary products and the sufficient installed base of users will lead to a higher market returns than the quality itself (Molina-Castillo et al., 2011). However, Goldberg et al. (2010) argue that the role of network effects in the diffusion process and its economic value associated with a new product is not prominent.

Despite the broad interest around the phenomenon's alterations and role in various contexts, the current research has mainly focused on consumer markets. Thus, the existing literature and theories have not been widely adopted in industrial markets. Neglecting the potential direct and indirect effects in B2B markets can lead to under adoption of new innovations and

create a start-up problem of the user-installed base. As Podoynitsyna et al. (2013) note, the product's value is not only depended on its attributes but also on the future number of users that will eventually adopt it. Thus, the importance of complementary products and services that are compatible with the focal product is also critical for network effects to occur (Katz and Shapiro, 1994; Pae and Hyun, 2002). As Molina-Castillo et al. (2011, p. 926) point out that "nowadays, customers pay attention not only to individual product benefits but also to the possible benefits of using a product in combination with other products or customers." This external product value source may as well apply in a high technology enterprise environment as the organization's workflows and processes are utilized by different hardware/software combinations. A survey conducted by Accenture (2018) indicates that industrial users of virtual technology have acknowledged many potential use cases where to apply the immersive technology. These included industries with high-risk working environments such as energy, manufacturing, or surgeons that are already experiencing the benefits enabled by immersive technologies.

According to Yoffie (1997), as the economy has become more interconnected, an increasing number of products e.g., in the computing industry, consumer electronics, and telecommunications industries, are generating network externalities. Thus, digitalization of products and services is transforming a variety of industries into markets with network effects and ignoring the potential presence of network effects can lead to under-adoption of the given technology (Lee and O'Connor, 2003; Stremersch, Lehmann and Dekimpe, 2010; Podoynitsyna et al., 2013). However, the role of network effects in today's economic environment is increasing and thus affecting firms' marketing strategies (Srinivasan, Lilien, and Rangaswamy, 2004). This market evolution driven by technological progress can change market dynamics, organizational collaboration in virtual environments, and the way how supplying companies communicate about the improved product benefits.

So far, the majority of the research in the field has focused on network effects in consumer markets, and the research on network effects in the industrial markets is under established. Tellis, Niraj and Yin (2008) stresses that the research in the field has studied the presence of network effects (Nair, Chintaguta, and Dube, 2004), the nature of network effects (Katz and Shapiro, 1985; Farrell and Saloner, 1985; Shankar and Bayus, 2003), or trying to interlink the phenomena and diffusion (Gupta, Jain, and Sawhey, 1999). More recently, the

phenomenon has aroused interest in B2B markets as well. Vowles, Thirkell, and Sinha (2011) empirically studied the factors which best explain B2B adoption of a radical, high-technology innovation early in the diffusion process. Their approach provided insights into the different determinants of adoption at different times in the product diffusion process. Interestingly, the early adopters did not perceive the future size of the installed base nor the strength of the complements network important factor in adopting decisions. They suggest that this outcome might be because compatibility becomes less of a concern for later adopters. Vowles et al. (2011, p. 1162) concluded their findings: "The influencers of earliest adopters appear to be innovation-focused: the perceived benefits of the innovation, as well as the strength of the producer network positively relate to early adoption". Further, Vowles at al. (2011) noticed that early adopters perceive the new technology as less different than its predecessor compared to later adopters.

Frambach (1993) argues that the current diffusion theory and marketing research has ignored the supplying company's role in the diffusion process. McDade et al. (2010) point out that in industrial markets, high technology products are characterized by uncertainty and switching costs and that the diffusion process among organizational adopters is still "largely a process of interpersonal communications" (McDade et al., 2010, p. 306). Thus, the swift rate of technological progress (Norton and Bass, 1987; Heide and Weiss, 1995), and the insufficient preceding experience by adopters is causing higher uncertainties and risks related to the product (von Hippel, 1986). This product uncertainty and commitments to existing systems are creating high perceived switching costs that may negatively affect the adoption of new technologies or systems (Heide and Weiss, 1995). As Vowles et al. (2011) point out, this multi-phase decision process becomes increasingly complex, especially in resource-scarce organizations, when the innovation incorporates high technology that is profoundly different from its predecessors and may require specialized knowledge to implement it. Hence, the supplying company of high technology products or services face multiple strategical choices regarding whom to target early in the product lifecycle and how to enhance the diffusion process (Vowles et al., 2011). To reduce the uncertainty within the target audience, one strategy is to identify individuals who central to a community and, thus, perhaps more influential within their organization. Regarding Valente and Davis (1999), one approach in B2B markets to facilitate diffusion is to target the messages for these individuals or opinion leaders.

Moreover, the industrial brand can decrease the perceived uncertainty and product risk. Academics have acknowledged that brand perception has an impact on the external view of product quality (Molina-Castillo et al., 2011) and how perceived brand utility affects the diffusion of innovative products (Choi, Kim, and Lee, 2010). Extant research in the industrial marketing field implies that supplying the company's corporate and product brands are valuable assets that impact competitive position and advantage in B2B markets (Leek and Christodoulides, 2012; Arnett, Laverie and Wilcox, 2010; McDonald, de Chernatony and Harris, 2001). Further, the purpose of brand development is to decrease buyer risk perceptions (Leischnig and Enke, 2011). Thus, brands appear crucial in B2B contexts where complex products require after-sales support or maintenance services (Mudambi, 2002).

The current research lack of studies in linking network effects and high technology product diffusion in B2B markets. A nascent immersive technology industry offers exciting context to study the characteristics of direct and indirect network effects. Moreover, as the industry and technology are continually evolving, standard designs will probably emerge at some point. The hardware/software nature of the product and overall advancements in computing technologies are creating an adequate market environment for network effects of evolving. Thus, the main focus of this thesis is to study whether the industrial virtual reality (VR) and mixed reality (XR) markets exhibit network effects and how does the enterprise users perceive the direct and indirect benefits in their adoption decisions.

In order to understand the NE phenomenon in industrial markets, a proper literature review must be conducted. While the relationship of network effects and industrial diffusion is quite understudied topic in current literature, both theories are discussed separately. The industrial brand is studied as part of industrial diffusion to reduce the perceived product risk and uncertainty. Moreover, the supply side role is adopted in the diffusion process, and the role of early adopters as first product users and disseminating information about new innovation is underlined. In the theoretical framework, these theories are comprised together to depict the relationship of network effects and diffusion in B2B markets.

1.2 Industry background

Despite the segments of the reality-virtuality continuum have witnessed fascinating technological advancements over the last decade, the definitions have remained relatively untouched since they first appeared in the literature back in the 1990's (Bekele and Champion, 2019). Bekele and Champion (2019) explain that especially in technology realm, it is a natural process for definitions and scientific assertions to continuously align themselves toward current advances. Next, we are going through the most common definitions of different immersive technologies and the evolution of them.

Milgram and Kishino (1994) developed the concept of a "*virtuality continuum*" where they classified the span between the physical and virtual environments to augmented reality (AR), virtual reality (VR), augmented virtuality (AV), and mixed reality (MR). According to Milgram and Kishino (1994), the concept of a "virtuality continuum" relates to the mixture of classes of objects presented in any particular situation, where the real and virtual environments are opposite extremums. The purpose of their study was to demonstrate the need for an efficient taxonomy and framework to clarify a various terminology issues regarding the different technologies in the continuum. In addition to their study, they particularly focused on defining the subclass of VR related technologies that involve the merging of real and virtual worlds, which they referred as MR.

The taxonomy of MR involved the merging of real and virtual worlds somewhere along in their "virtuality continuum" which connects completely real environments to completely virtual ones. They define Augmented Reality (AR) in which the display of an otherwise real environment is augmented by means of virtual objects. Contrary to MR and AR, Virtual Reality (VR) is an environment in which the user is fully immersed in, and able to interact with a completely virtual world. The real environments consist purely of real objects whereas virtual environment consist solely of virtual objects. Therefore, Milgram and Kishino (1994) defines MR as a situation, where real and virtual world objects are presented together within a single display, that is anywhere between the extrema of the their virtuality continuum.

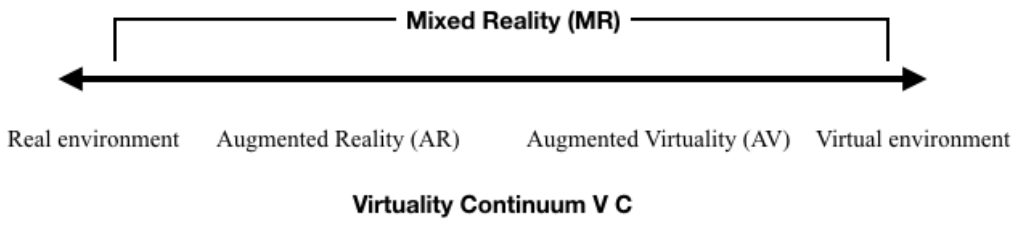

Figure 1. Virtuality Continuum by Milgram and Kishino (1994)

Recently, the taxonomy of immersive technologies has evolved because of the development of the technologies, graphics and wearables. According to Fast-Berglund, Gong and Li (2018), extended reality or mixed reality (XR) denotes to a situation where all real and virtual combined environments and human-machine interactions are generated by computer technology and blends seamlessly in wearables. VR, MR, and AR can be defined as different types of XR technologies. Therefore, XR can be seen as umbrella category that covers all the various forms of computer-altered reality. For that reason, the MR is also a subcategory of XR and the modified *virtuality continuum* is presented below in figure 2. The definition of XR is also important in regard of this study because the case company is a manufacturer of HMD devices (hardware) and developer of workspace application (software) with VR and XR -extensions.

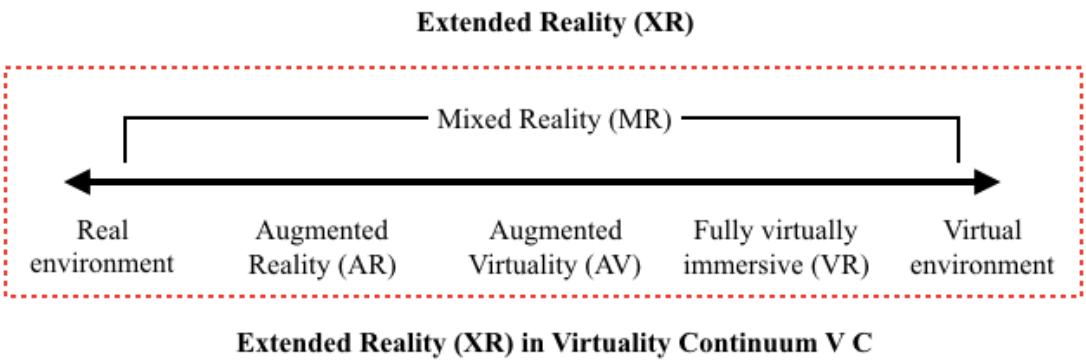

Figure 2. Extended Reality (XR) in Virtuality Continuum. Adopted from Milgram and Kishino (1994) and Fast-Berglund et al. (2018).

Since their study of a taxonomy of MR visual displays (Milgram and Kishino, 1994), both hardware and software technologies have experienced rapid advancements in the immersive technology industry. Beleke and Champion's (2019) research was based on the recognition that the definitions of the reality-virtuality continuum have continued to appear unchanged, still being referred in their original forms. They presented a redefinition of the *reality-virtuality continuum* (Milgram and Kishino, 1994) from a perspective that emphasized the interplay between users in the virtuality and reality environment as a central basis. They argued that current literature appears to approach AR as an alternative to MR, and MR is usually considered to encompass AR and VR, rather than specifying it as a separate entity along the reality-virtuality continuum. Beleke and Champion (2019) argues the most common definitions of immersive technologies in current literature are based on outdated display technologies. Hence the relationship between virtual and real environments is failing to stress the importance of the users necessarily complicit sense of immersion from the relationship. (Beleke and Champion, 2019)

Beleke and Champion (2019) used Milgram's and Kishino's (1994) *virtuality continuum* framework as a basis for their study. In their study, Beleke and Champion (2019) stressed the importance to redefine the concept of MR and to update the *virtuality continuum* framework. Regarding to Beleke and Champion (2019), there are three aspects that should be acknowledged in the immersive reality studies regarding the AR and MR definitions in the continuum. Firstly, AR and MR are perceived as alternates, and secondly, MR is perceived as a combination of AR and VR. Lastly, users are excluded from the defining relationship between reality and virtuality.

According to Beleke and Champion (2019), the sole purpose of AR is to enhance our perception of the real world by imposing virtual information on top of our view to the real world. Whereas, virtual reality (VR) is often referred as a segment of the reality-virtuality continuum that transports users into a computer-generated virtual world, where they are expected to experience a high level of presence in the environment (Steuer, 1992). Virtual environments detach the user's sense of being here and now in the physical world by creating artificial presence in a virtual one instead. The vast advances in VR have enabled virtual environments to deceive our hearing, visual, and kinaesthetic senses. Moreover, VR has the potential to simulate imaginative and existing physical environments along with their

processes and environmental parameters to engage and affect all of our senses including touch and smell. Whereas augmented virtuality (AV) augments virtual environments with live scenes from the real-world events and is commonly understood as a variation of VR. But the sole purpose of augmenting virtual environments with live scenes is to enhance our understanding of the underlying virtual environment. In terms of purpose, AV is closely aligned to AR because both aim at enhancing the environment they are applied to. (Beleke and Champion, 2019)

Within the industry and researchers, there are instances where the terms AR and MR are used interchangeably (Raptis, Fidas and Avouris, 2018). Beleke and Champion (2019) argues that both immersive technologies share a common objective, that is enhancing our understanding of the physical environment to some extent. In their study, they define a distinction between AR and MR segments in reality-virtuality continuum. AR is enhancing our understanding of the physical environment by overlaying digital content over our view of the physical world and this portion of the continuum is placed closer to reality. Whereas MR achieves a broader goal by enhancing our understanding of the real and virtual worlds where the elements of the real and virtual environments blends seamlessly. Academical literature supports Beleke's and Champion's (2019) arguments about the distinction between AR and MR. In their report, Leach et al. (2018) discussed that AR has a limited visual and spatial immersion contrary to MR. Thereby, MR combines interactivity and immersion from AR and VR, respectively, to bring immersive-interactive experience to our view of the real-virtual world. Thus, MR combines different properties of the continuum into a single immersive reality technology (Beleke ja Champion, 2019).

Below in figure 3, is presented Beleke's and Champion's (2019) redefined framework of the original continuum (Milgram and Kishino, 1994) from a perspective underlying the important relationship and interaction between users, reality and virtuality. Their user-centric model stressed the user's experiential and interactivity perspectives in the real-virtual environments. Thus, they redefined MR as an integration of elements from virtual and real environments that allows users to interact with both worlds that benefit from each other's elements in order to enhance user's understanding of the two worlds.

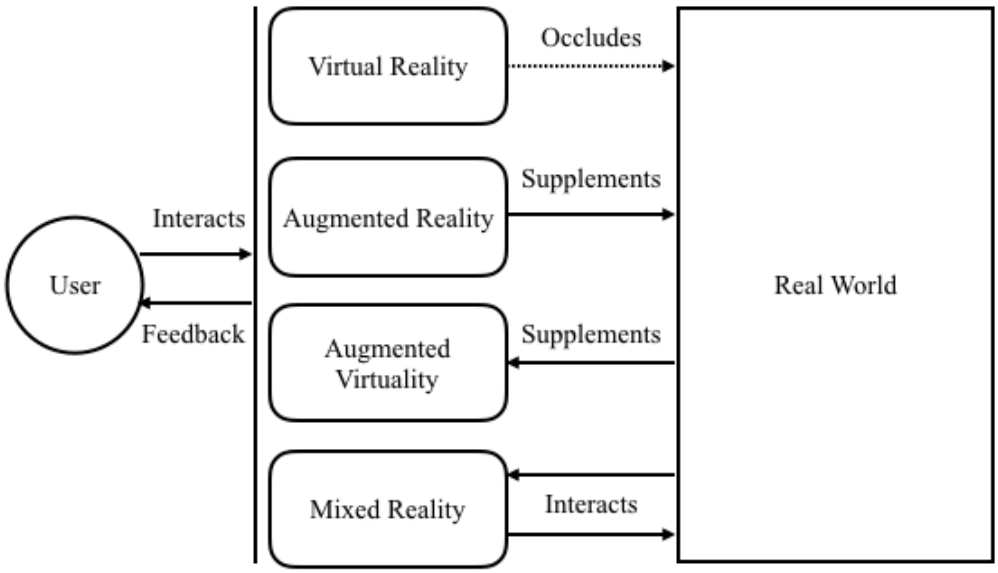

Figure 3. User-Reality-Virtuality (URV) Interaction: Interaction between users, display technologies and the real world (Beleke and Champion, 2019).

This user-centric approach for interacting with real-virtual environments is playing an increasingly important role, especially in industrial use. Companies that deploy immersive technologies as part of their workflows and toolchains, enhanced user experience and interactivity possibilities are creating better collaborative opportunities to utilize the product. These basic concepts of VR and XR are good to distinguish in order to understand the nature and context of the studied high-technology product. Further, this interaction between users, HMD's and the real world are focal in enhancing the user experience and virtual collaboration in organizations. Next we are discussing about the development of immersive technology markets and future expectations.

1.2.1 Immersive technology markets

The technological advancement and increasing investments in the immersive technologies are showing strong optimism toward the future role of the technology within different industries (PerkinsCoie, 2019). Especially, the potential of digital manufacturing has been seen as a highly promising set of technologies for reducing product development times and

cost as well as improved customization, increased product quality, and faster response to the market for a while (Chryssolouris et al., 2009). Immersive technologies could be utilized in various areas where bridging digital/cyber/virtual and physical worlds could save a lot of time in manufacturing processes such as i.e. design (Lawson et al., 2015), prototyping (Seth, Vance and Oliver, 2011), immersive learning (Accenture, 2018), marketing, logistics (Hanson, Falkenström and Miettinen, 2017), maintenance (Borsci, Lawson and Broome, 2015), set-ups, remote guidance and assembly (Fast-Berglund, Gong and Li, 2018).

This shift toward virtual environments are further driven by the industry 4.0 revolution and the uptake of increased digitalization, and organizations must acknowledge the changes in their competitive environment (Accenture, 2018). Technologies are becoming more interconnected and new technologies are disrupting the traditional requirements of the workforce. One of the most interesting emerging technologies is the rise of immersive technology. According to survey conducted by Perkins Coie LLP and the XR Association (2019), by the year 2025, immersive technologies of XR, AR, VR and MR will be as ubiquitous as mobile devices. The broad optimism among the respondents signals the enormous potential of immersive technologies in the future. Even though the potential of the immersive technologies has been acknowledged by many experts within various industries, different barriers to adoption exists. (PerkinsCoie, 2019)

When the respondents were asked to select up to 3 options in industries where they believe XR is most applicable currently, gaming (61%), healthcare and medical devices (41%), education (41%) and manufacturing and automotive (23%) were the top 3 choices. The industry sectors where the respondents expected to see the most investments directed to the development of AR/VR/MR/XR technologies or content in the following year were gaming (54%), healthcare and medical devices (43%), education (36%), military/defense (28%) and manufacturing and automotive (20%) (PerkinsCoie, 2019). Research study done by Fortune Business Insights (2018) supports the same key trends and future applications of immersive technologies as mentioned by respondents in the survey conducted by PerkinsCoie (2019). Fortune (2018) based their VR market growth potential to signs of increasing supply of applications and adoptions in the industry verticals such as healthcare, education, automotive, manufacture, and aerospace and defense. Especially, workforce education in

VR-environments enables many companies to place their employees in situations and circumstances which they are probably going to experience at work (Accenture, 2018).

1.2.2 Current market size and future expectations

Fortune Business Insight report (2018) estimated that VR market size value was 7.3 billion USD in 2018 and they predicted it to reach 120.5 billion by 2026 exhibiting a CAGR of 42.2% during the forecast period. Statista (2019) shared similar growth expectations for the AR and VR market, with a forecast 16.8 billion USD in 2019 and potential to eclipse 160 billion USD by 2023. Market Watch (2019) is much more moderate in their future market growth predictions. They are expecting the global VR market to exceed more than 43 billion USD by 2024 at a CAGR of more than 33% in the given forecast period. A report done by Market Research Engine (2018) share similar moderate expectations as Market Watch (2019). According to their metrics, the global VR market is expected to exceed more than 43 billion USD by 2024 with CAGR of more than 33% in the given forecast period. Even though there are notable variance in the global market growth estimates, the reports are still expecting huge growth and investments in the immersive technology industries.

The reports based their growth expectations of global virtual reality markets in the following sources. Both research companies Market Watch (2019) and Market Research Engine (2018) saw huge growth potential in use of VR for training and imitation in defense. Another source for market growth was the gaming and entertainment industry where the rising acceptance of HMD's speed up the adoption on immersive technologies. Especially, utilizing XR in workforce development can gain lower costs, increase employee engagement and companies are able to mirror real-life situations. Thus, companies in energy, industrial, manufacturing and construction industries have already utilized XR part of their operations according to research conducted by Accenture (2018).

Even though the enormous optimism toward the evolution of VR technology markets, there are still obstacles to overcome to reach critical mass of users. The hardware and software in the industry are constantly evolving to respond the high demand of consumers in B2C and B2B markets. Market Watch (2019) and Market Research Engine (2018) both listed the same restraining factors for mass adoption of VR. The virtual device display latency and power consumption are concerning analysts in different industries. Another restraining factor is low

resolution of the existing devices that is seen as a major barrier for lagging the adoption. Regarding the survey (PerkinsCoie, 2018), the biggest obstacles for mass adoption of VR technologies were user experience (27%), such as bulky hardware or technical glitches, consumer and business reluctance to embrace VR and content offerings (19%). Among the respondents, 39% said that the uncertainty regarding the viability of the software is the biggest challenge when considering co-operation with companies developing immersive technologies. One of the respondents in the survey noted that the future of immersive technology will not be with the consumers, instead people will consume the technology in a more secondary way, such as in doctors' offices or schools. For that reason, AR and VR can be seen as an important work tools in the future. Moreover, the overall development of technologies such as 5G network, edge and cloud computing will drive the change from traditional 2D screens to more immersive experiences and 3D environments.

1.2.3 Virtual reality ecosystem

As e.g. in PC and mobile phone markets, the final product is a combination of hardware and software. Same applies to immersive markets where companies can also be divided into hardware and software producers/developers. The following division into hardware and software developers is not thorough and should not be taken as given. For example, there are many subcontractors and chip manufactures in the supply chain to contribute the final product, but regarding this study the following dichotomy is natural and easy to understand. The VR ecosystem is visualized below in figure 4 to help the reader to understand the domains of the immersive industry. The hardware and software categories are split into subcategories and the case company's position in the VR ecosystem is highlighted in red. Thus, the case company is the developer and manufacturer of head mounted displays (HMD) and workspace software. Next we are going through briefly each subcategory to gain deeper understanding of the underlying characteristics of the value drivers for the user experience and compatibility between systems.

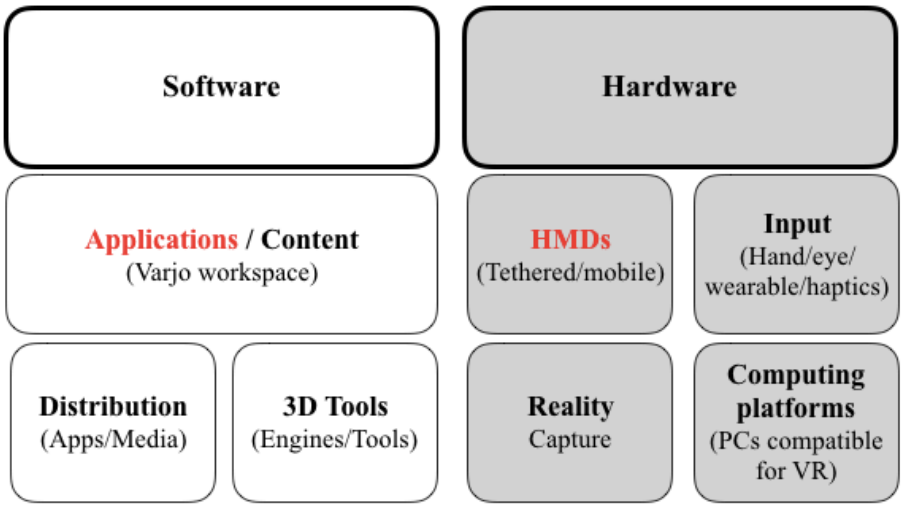

Figure 4. Case company position in the virtual reality ecosystem map. Adopted from Chennavasin (2017).

Hardware

Reality capture is the discipline that performs indirect measurements of natural space by using different photography and measuring techniques. Reality capture includes the process of extracting data from 2D images and mapping them onto the 3D environment. Beside capturing as-built information, the other important dimension of the reality capture is to integrate the information seamlessly in CAD or other deployed engineering systems. (Frei, Kung and Bukowski, 2005)

Head mounted displays (HMDs) are designed for immersive virtual environments to enable large spatial visualization to employ immerse users into data graphics. Ball and North (2005) notifies that high-resolution HMD's have improve perception and navigation for visual tasks. Immersive display technologies with high quality resolution are expected to open possibilities for new use-cases within industries and enable enterprises to fully deploy them as a standard-operations (Cordeil, Dwyer, Klein, Laha, Marriot and Thomas, 2017; Accenture, 2018).

Input devices are different technologies that enable users of immersive technologies (VR, AR, MR, XR) to interact with their virtual environment and thus, increase the user experience. Common input devices are wearable controllers such as different kind of haptics

or integrated data feedback systems such as eye- and hand-tracking. Companies that develop gadgets and input technologies share a common purpose of bringing the user's body and senses into a virtual environment.

Computing platforms are companies that develop graphics processing units (GPU) or central processing units (CPU) for virtual reality and immersive HMDs. Head mounted displays are graphic intensive units that requires the appropriate powerful hardware platforms for running the software and VR content in them. The development and utilization of 5G networks are also improving the wireless VR ecosystem enabling faster internet and data processing times.

Software

Application/content developers are companies that create content and applications for compatible immersive (VR/AR/MR) technology hardware manufacturers. These companies such as Sony or HTC are sometimes developers of hardware also, such as HMDs, input devices and distribution channels. Recently, the case company introduced their in-house software application Varjo workspace. It is a dimensional interface allowing 2D and 3D to merge into a multiscreen view with their XR HMD unit. Typical strategy is to partner with hardware manufacturer and use the HMDs, input devices, 3D tools and distribution channels to create unique applications that can provide better user experience for end-customers.

3D Tools are companies that create software tools that enable different content creation for VR platforms. The typical content created for virtual environments are computer generated images (CGI) and earlier mentioned reality capture techniques. The developers of 3D tools are very central to the content creation in VR industry. An ideal goal for 3D tools is to standardize various development functions and "democratize" best practices to enable collaboration between hardware and software developers. Unity is a well-known product platform in the industry and its platform includes core functions, libraries, and digital assets to enhance and develop VR experiences for various users and use-cases.

Distribution include on-demand platforms where the applications can be found and downloaded. The distribution channel companies gather together the available applications and content for end-users. The distribution of VR compatible applications is similar to Apple Store where the user can download the content. For example, Facebook is developing its VR

product Oculus Rift toward gaming platforms and believes the VR will enhance people's lives in the future. This distribution of content and computing power can significantly improve in the future due to the development of edge and cloud computing.

To sum up this chapter, the potential of immersive technologies has been acknowledged in many industries. Despite the vast optimism toward the immersive technologies, barriers for adoption exists in B2B markets as the market surveys conducted by PerkinsCoie (2018,2019) and Accenture (2018) illustrated. The situational analysis of the industry was mandatory in order to build a coherent picture of the industry characteristics and understand the context of this study. The new high-technology innovation in emerging markets, and lack of prior experience can cause uncertainties in adopting organizations. Thus, utilizing network effects and role of early adopters can facilitate future diffusion of the innovation in B2B markets and thus, develop industrial brand as a source of credibility.

1.3 Focus of the Study: Research Questions

The objective of this research is to study does the case company's head mounted display (HMD) exhibit direct and indirect network effects in their target markets and partner network. The existing literature lack of comprehensive studies about the role of network effects in industrial environment and product diffusion. Hence, the diffusion characteristics of emerging high technology product in the B2B markets offers interesting opportunities for research in the field. Advancements in immersive technologies and growing digitalization of traditional organizational processes are disrupting industry verticals to stay competitive in the digital revolution.

Research about the critical drivers of new product performance have intrigued researchers in the academic field for decades. Product quality is usually considered a crucial or *de facto* attribute to obtain a competitive advantage in the markets. As products and technologies become more interconnected, the traditional critical success drivers of new high technology products should be critically re-evaluated. For decades, researchers have studied network effects (Farrell and Saloner, 1986; Katz and Shapiro, 1986) and more recently the research stream have studied the role of network effects in the new product performance context. In their research, Tellis et al. (2008) concluded that quality alone does not explain product performance and the interaction between quality and network effects can improve market

efficiency. Another study by Molina-Castillo et al. (2011) examined the effects of product quality, switching costs and network effects to products short/long term performance. They suggest that beside product quality, indirect network externalities play a key role in the short term, whereas direct network externalities are more determinant in the long-term product success (Molina-Castillo et al., 2011). In addition, they argue that both indirect and direct network externalities increase perceived switching cost which "lock-in" the customers to given system. As they concluded that "if a customer devoted a lot of effort to learn from other complementary products (indirect network externalities) and from the relationship with other customers (direct network effects), this would have a positive long-term impact that would go beyond the objective quality of the new product" (Molina-Castillo et al., 2011, p. 925).

Even though the extant studies in various discipline acknowledges the diverse impacts of network effects, the academical research has mainly focused on proving the presence, nature or analyzing the role of network effects in diffusion of innovation (Nair et al. 2004; Katz and Shapiro, 1986; Gupta et al., 1999; Choi et al., 2011). Another argument to support the urgency of this research is that the existing literature and empirical data has been mainly conducted in the B2C markets. The typical product categories and theories are induced form consumer markets as the examples of diffusion of VHS, DVD and ATM systems demonstrates. There is no comprehensive research evidence that can the network effect theories be applied in the B2B -markets as such and what are the implications. Thus, the first research question investigate the characteristics of network effects to find potential evidence and relationships that could be applied in the B2B context in order to improve the high-technology product performance.

RQ1. The characteristics of network effects in B2B markets? Role of direct and indirect value sources in product diffusion.

As described in previous chapters, digitalization and significant advancements in immersive hardware and software technologies are shaping market dynamics. Thus, organizations may face questions when and how to update their systems that are crucial in their workflows. Usually, high technology industries that are technology and knowledge intensive are

potentially influenced by direct and indirect network effects (Podoynitsyna et al., 2011). Using the current literature to build a framework and exploited by empirical data collected from case company's network partners, the objective is to understand how the case company, their end users and partners perceive the importance of network effects. Thus, in order to obtain competitive advantage, increase installed base and enhance the diffusion of the immersive product in the target verticals, the second research question (RQ2) is:

RQ 2: How to utilize network effects in the high technology product diffusion process in B2B markets?

To ensure the early adaptation and diffusion of the new product, companies must make strategical decisions about marketing tactics and their key partners. Many supplying companies may face challenges in industrial markets, especially when they are new startups introducing high-technology innovations. Hence, their product or service must overperform its predecessors in the markets in terms of quality and performance. Moreover, buying organizations are rather conservative and rational in their purchase decision, so supplier and end-user relationships must be built to reach credibility and trust. Therefore, the industrial brand can be seen as a reputation and source of credibility that can decrease the perceived risk and uncertainty toward the new innovation and organization.

As mentioned in the background section, Molina-Castillo et al. (2011) and Choi, Kim, and Lee (2010) suggested that future studies in network effects literature could study the role of the external perception of product quality such as the suppliers perceived brand. Leek and Christodoulides (2012) point out that academics have identified various benefits of industrial brand equity to the supplier company. Thus, Cretu and Brodie (2007) remind that branding has been found to have a positive impact on the perceived quality of the product, and the intangible benefits can decrease the level of risk and uncertainty in the organizational purchase decision (Mudambi, 2002). The role of industrial brand in product diffusion context is studied as a source of credibility and trust, reducing the perceived risks in the purchasing process. The second research question (RQ3) of the study is:

RQ 3: The role of brand in industrial diffusion, a source of credibility and trust?

The third research question aims to study existing literature about the role of brand in industrial markets and how the concept of the brand is interpreted among the sample group. Therefore, the industrial brand is studied as a source to decrease the perceived product risk in industrial markets. Also, collaboration and joint-brand communication strategies with selected early adopters are studied as a source of disseminating information about the new innovation within the target segments.

1.4 Theoretical framework

In this section, the background of the theoretical framework (figure 5) will be explained. The proposed framework for industrial diffusion of high technology product enhanced by network effects integrates three primary constructs: (1) high technology product, (2) industry opinion leaders (early product users), and (3) compatible software and service partners. Consequently, the perceived product value is a sum of the quality and performance of the focal hardware, compatibility with leading third-party software applications, and complemented with other value-adding products and services. This co-creation of value between industry partners creates credibility and trust, thus decreasing the perceived risk and uncertainty for early adopters. Ultimately the product success in the markets is determined by the product performance that can further drive the growth of the installed base and availability of new software applications.

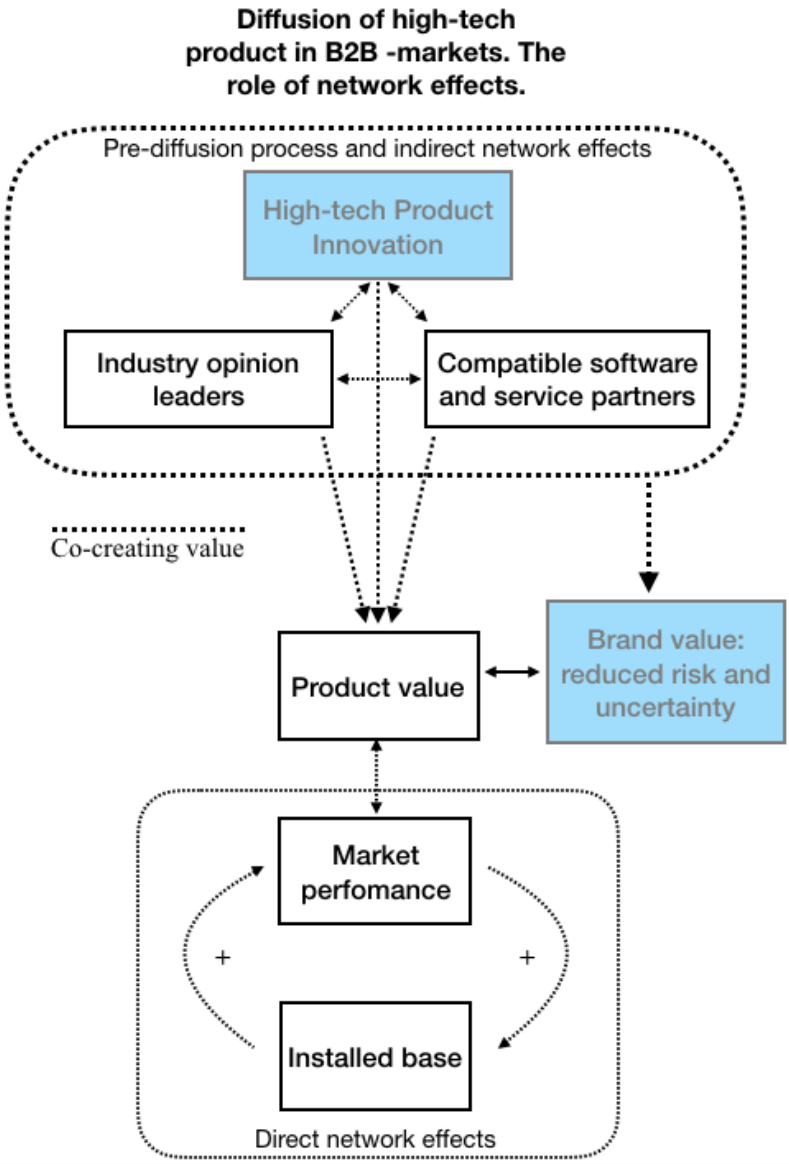

Figure 5. The research framework applied in the study.

The research framework comprises the context and the main theoretical concepts used in this study. The premise of this research is that the case company's target end customer segments in the B2B markets are influenced by direct and indirect network effects. Therefore, the objective of this research is to examine the characteristics of network effects in the organizational environment and whether the markets exhibit direct and indirect network effects. Previous studies and current theories applied in the literature will be explained more in-depth in the following chapters.

Today, the digital economy and the interconnection of technologies are a huge catalyst to accelerate consumption externalities in various markets and environments. Current literature and industrial marketing research support the notion that a variety of industries are affected by network effects (Katz and Shapiro, 1994; Podoynitsyna et al., 2013). Thus, companies that are competing in knowledge-intensive industrial markets should acknowledge the role of network effects in their product or service design. Therefore, the purpose is to build a holistic understanding of the phenomenon and examine the underlying factors that facilitate direct and indirect value for end-users. If the key decision-makers have a proper understanding of the presence and nature of the phenomenon in industrial markets, they are better informed to make future decisions in their business environment.

The purpose of the first research question (RQ1) is to investigate the role of NE in the new high technology product diffusion process in the B2B -markets. The second research question (RQ2) further studies the implications of NE in the case company's target markets. The current literature has focused on the topic more thoroughly in the consumer market context. In contrast, organizational diffusion process and adoption dynamics are affected by different decision-making phases, switching costs, marketing strategies, and in-house organizational capabilities. Moreover, emerging immersive technologies such as VR and XR are gaining a foothold in many companies as a part of their daily working tools and operations, which offers an exciting perspective to investigate the topic. In the future, the growth of userbase in immersive technologies across industry verticals and new software applications will enable improved virtual collaboration within organizations. Thus, the probability of direct and indirect network effects in B2B markets should be distinctive. Therefore, the first research question aims to examine how the case company could utilize direct and indirect network effects in its target verticals. Hence, the idea is to find evidence of whether the installed base of users and compatible software applications affect the perceived value of the product. To examine these interconnections, the literature is supported by qualitative interviews with industry experts such as the case company employees, their early end-users, and software partner to diversify the perspectives and incentives.

The third research question (RQ3) studies the industrial brand from the perspective to decrease the perceived product risk and uncertainty. Leek and Christodoulides (2012, p. 109) note that in the past, "B2B buyers have been perceived as focusing predominantly on the

rational aspects of decision making and giving less consideration to any emotional elements". Thus, lately, the researchers have noted that emotion in branding has become more apparent through the manager's responses, and consequently, supplying companies have acknowledged that brands reduce buyer's perceived risk (Leek and Christodoulides, 2012). Hence, many new startups face challenges in establishing a trustworthy reputation. Their product/service will be evaluated and tested before the initial sale is eventually made. Hence, the company has to build a trustworthy reputation through product quality and earn credibility by delivering value that they have promised. However, buying organizations may perceive high risks and uncertainty toward new technology startups because many of them fail to survive in the long term.

In order to empirically study the presented research questions, a robust understanding of the underlying theories must be built. After a proper literature review and theory background investigation, the subject can be analyzed in practice. The idea of the literature review is to cover all the essential theories regarding the context of this study. The proposed framework of this study is a synthesis of the core theories in the network effect literature and diffusion of innovation in organizations. Previous studies about network effects and diffusion of innovation in consumer markets indicate positive relationship with product performance. The value drivers of direct and indirect network effects are the main facilitators of the successful utilization of the phenomenon. Hence, building a product network where the utility for the user increases as more new users join the same network, and ensuring the availability of compatible software applications are essential strategical implications for companies, who aim to establish their product successfully in industrial markets.

Direct network effects will be studied in the context of the product's installed base. The purpose is to investigate can the case company's HMD utilizes direct intra- and interorganizational value. For instance, can the company's VR/XR immersive technology be interconnected with two or more devices in the same virtual environment at the same time? Reciprocity between users could increase virtual collaboration opportunities and create positive feedback effects. Indirect network effects arise when the availability of compatible software applications and complementary goods are sufficient to utilize the hardware. Hence, the system coordination between hardware/software developers is essential to ensure system interoperability and unlock potential end-users. Therefore, the

system compatibility can be seen as a strategical choice whether the company chooses to make its product incompatible or compatible.

1.5 Structure of the Thesis

The structure of the thesis proceeds as follows. The previous introduction chapter focused on introducing the background of the study context and arguing the significance of this study. Also, the characteristics of the case company's markets were briefly represented to build a coherent understanding of the emerging immersive industry.

The literature review starts by presenting the main literature themes applied in the research framework. First, network effects literature and its main concepts are studied. Then, the dynamics of industrial diffusion are brought into the discussion, and the role of opinion leaders in the diffusion process is analyzed. Finally, the literature review is brought together by investigating the nature of industrial brands to decrease the perceived product risk and uncertainty. These theories are comprised of identifying relationships and linkages to enhance the industrial diffusion of new high-technology innovations.

After we have built a thorough understanding of the current academical findings regarding the chosen theories, the research design and methodology are presented. That section aims to justify the selected research approach and explain how the semi-structured interviews were conducted. Moreover, a detailed explanation of the chosen qualitative data collection and interpretation methods are presented. Finally, an evaluation of the principles that were used to ensure the validity and reliability of the research are discussed.

In the results and discussion chapter, the findings of the study are reflected in the theoretical framework and current theories. In the final chapter, the conclusions of the research are summarized to guide practical managerial implications and future research streams.

2 LITERATURE REVIEW

The prior research stream in the field has focused on the presence of the network effects, investigating the nature of the phenomenon and analyzing its role in the diffusion process (Tellis et al., 2007). The phenomenon has intrigued researchers rather long, and it has been given different names in the past, but in this research, we will use network effects (from now on NE). The NE phenomenon has got multiple designations among researchers, such as positive/negative network externalities, installed-base effects, adoption externalities (Katz and Shapiro, 1992), interactive network externalities, and centralized/decentralized network externalities to mention a few (Lee and O'Connor, 2003). Despite interchangeability and several designations are given the phenomenon, academics agree that the effects of NE are unambiguous and approve the distinction between direct and indirect NE (Molina-Castillo et al., 2011).

Even though there are some inconsistency and diversity in the used terminology to describe the phenomenon, researchers generally agree that NE can be divided into direct network effects (Farrell and Saloner, 1985; Katz and Shapiro, 1986; Shurmer, 1993) and indirect network effects (Arthur, 1994; Sheremata, 1997; Shurmer, 1993). By analyzing the current empirical findings in the literature and reflecting them on this research gives an excellent basis to analyze the possible role of NE in case the company's new high-technology product diffusion and product performance. Besides studying the potential role of NE enhancing the diffusion of high technology products in B2B markets, the role of the industrial brand will be studied in the diffusion process as a factor decreasing the related product/organizational risk in a nascent industry.

In this chapter, we are defining the concept of NE and its different subcategories, such as direct and indirect NE. The NE also includes important sub-concepts such as i.e., *installed base*, *critical mass*, *hardware-software paradigm*, and *compatibility*. Acknowledging these subcategories of the phenomenon is the basis for understanding the characteristics of NE.

2.1 Network Effects: The concept and related constructs

The pioneers of NE research, Katz and Shapiro (1994, p. 93) stated that "many products have little or no value in isolation but generate value when combined with others". This

conventional for products that are strongly complementary and together they form a system. Katz and Shapiro (1994) defines that forming systems refers to collections of two or more components with an interface that allows the components to work together. Hence, in system markets, NE refer to the market phenomenon in which the value of a product or service to consumers depends on the number of users of that product or service (Katz and Shapiro, 1986; Wang, Chen and Xie, 2010). Thus, the larger is the installed base of the selected technology, the greater benefits each user receives using compatible products (Katz and Shapiro, 1992). According to Wendt and Westarp (1999), this positive network effect derives from the willingness to adopt a product innovation that positively correlates with the existing number of adopters. As Katz and Shapiro (1994, p. 94) argues in their research, that "because the value of membership to one user is positively affected when another user joins and enlarges network, such markets are said to exhibit `network effects` or `network externalities`". Therefore, the NE phenomenon denotes to a situation where value is not solely determined by the product features but also on the availability of complementary products or the existing userbase with whom the customer is able to interact with (Sahay and Riley, 2003; Katz and Shapiro, 1994). Consequently, potential adopters pose expectations about the future size of the installed base of the technology, and the availability of software, since new products rarely function in isolation (Gupta et al., 1999; Shocker, Bayus and Kim, 2004). This effect mainly originates from two different sources, the need of compatible products, and the need for complementary products and services (Katz and Shapiro, 1986; Economides, 1996). The former value source is called as *direct*, and the latter as *indirect* NE that are discussed separately later in this chapter.

Podoynitsyna et al. (2013) describes the dynamics of NE markets where the value of the "networked" product to adopter is a combination and derives from two different sources:

1) *Intrinsic value* refers to features and attributes of the product, hence the stand-alone utility, that is independent of the number of other users (e.g. personal computer), and utility derived from the augmented product (Lee and O'Connor, 2003),
2) *extrinsic value* refers to the set of benefits derived from outside the product itself, thus the networked utility (installed base of users and availability of compatible/complementary products) that results from other users in the physical or virtual network (Srinivasan et al. 2004; Lee and O'Connor, 2003).

Lee and O'Connor (2003) distinguishes the intrinsic and extrinsic value and explains how they differ between NE and nonnetwork effects products. The *intrinsic* product value includes the features/attributes that are designed into the product itself and all the experiences that user derive from the augmented product. In contrast, *extrinsic* value source is unique to NE products, thus generating value outside the product itself. The utility is derived from the installed userbase and the availability of compatible and complementary goods that enable more versatile use of the focal product. Thus, where the intrinsic value of a product is constant, the extrinsic value varies in the NE context, depending on the relative size of the existing userbase and complementary product and/or service availability. In contrast to user experience with 'nonnetworked' products or commodities, users derive value from intrinsic product attributes but moreover from its extrinsic value such as links to other products and users. Hence, given the characteristics of NE products and external value sources, many studies (e.g. Lee and O'Connor, 2003; Katz and Shapiro, 1992) argues that the future installed base of users is a critical determinant of success for a NE product.

Srinivasan (2008) argues that so far, current research has failed to contribute practitioners of how to design networked products and how it would influence on new product performance. Even though the phenomenon has intrigued researchers rather long and ignited multidisciplinary studies within many domains. Still, the studies have focused on investigating the phenomena from the economic perspective and used game theory to analyze its role in monopoly markets (Katz and Shapiro, 1985,1992,1994; Farrell and Saloner, 1986). Liebowitz and Margolis (1994) explain that these early studies paid special attention on the perverse effects and inefficient markets that NE are said to generate. More recently, the diversity in the field has evolved because of increasing digitalization and interdependencies in high technology system markets (Choi et al., 2010; Podoynitsyna et al., 2013; Lee and O'Connor, 2003; Molina-Castillo, Munuera-Alemàn and Calantone, 2011) but the outcomes of the phenomena in B2B markets are still rather understudied.

The empirical approaches to NE has traditionally studied the presence of NE by using quantitative analysis (Nair, Chintagunta and Dube, 2004; Katz and Shapiro, 1992) that investigate the nature of network effects (Shankar and Bayus, 2003; Katz and Shapiro, 1992;1994), analyze the role of NE in diffusion process (Choi et al., 2010; Gupta, Jain and

Sawhney, 1999), its effects on pioneer survival (Srinivasan, Lilien and Rangaswamy, 2004) or investigate the performance of new technology ventures under direct and indirect NE conditions (Podoynitsyna et al., 2013). But from the standpoint of this thesis, it must be noted that majority of these studies have been conducted in consumer market context. Beside Vowles et al. (2011) study, the past research stream lack the focus on linking NE and industrial diffusion in enterprise markets.

Typically, the pace of innovative activity and the introduction of new technologies are important dimensions of market performance and distinctive in NE markets (Katz and Shapiro, 1992). Thus, "the presence of these adoption effects can profoundly affect market behavior and performance" (Katz and Shapiro, 1994. p. 96). Given the rapid phase of technological advancement in global markets, people become increasingly connected beyond the industry and market boundaries, thus transforming a variety of traditional markets into markets with NE (Stremersch, Lehmann and Dekimpe, 2010; Wuyts, Dekimpe, Gijsbrechts and Pieters, 2010). Consequently, recent studies have shown that direct and indirect NE are present increasingly in various industries and markets, where the impact of externalities differ among different product categories (Goldenberg, Libai and Muller, 2010; Schilling, 2002; Srinivasan et al., 2004). Hence, these factors, that are constantly changing the market dynamics in industrial market also, the NE can profoundly impact the company's success. So, if the supplying company is working on high technology markets and developing a product that could potentially generate NE, it should be aware of the two different value sources: direct and indirect NE. These concepts are important to distinguish and understand to fully utilize NE in the product diffusion. Next both concepts and their sub-concepts are discussed separately.

2.1.1 Direct network effects

Weitzel, Wendt and Westarp (2000) point out that in various markets the buying decision of one consumer have influence on the decision of others. These interdependencies are broadly studied in economic literature and such effects as bandwagon, snob and Veblen are examples of this behavior (Leibenstein, 1950; Ceci and Kain, 1982). Thus, when the utility of a product to each user is positively affect as new user join the network, the product is said to exhibit direct NE (Katz and Shapiro, 1986). In addition, Katz and Shapiro (1986) argues that it is commonly agreed that direct NE are caused by demand side user externalities.

Hence, the value of direct NE is derived externally, thus when the value of a good to any user is an increasing function of the network's size operating the same compatible system commodity (Katz and Shapiro, 1986; Farrell and Saloner, 1986; Schoder, 2000). Simply, the positive direct NE arises from the growing number of users that adopts the same good (Lee and O'Connor, 2003) but occur only with use, purchasing the good is not sufficient (Schoder, 2000). Research literature has used ambiguous definitions to describe the same phenomena, such as *demand-side economies of scale* (Katz and Shapiro, 1986) and *economies of mass adoption* (Norsworthy and Lee, 1998). Lee and O'Connor (2003) use classical example of direct NE. The value of fax machine network is based on the utility from growing number of users as each user in the network have more potential recipients to send faxes to.

Thus, this external value derived from other users in the same network positively affects the willingness to adopt same product to grant access in the network (Weitzel et al., 2000). According to Wendt and Westarp (1999), this buying decision behavior and interdependency between current users is evident in technology intensive markets such as information technology and telecommunication markets. Regarding to Weitzel et al. (2000), the NE in these markets derives from two different sources, the need for compatibility to exchange information or data and the need for complementary products and services. Lee and O'Connor (2003) found similar empirical evidence that the transformation toward more interconnected economy is generating NE in technology and knowledge intensive markets. Consequently, Shankar and Bayus (2003) argues that the impact of direct NE on customer behavior and market structure have given promising results. According to Bayus, Jain and Rao (1997), once the new innovation has been accepted in the target markets, it can substantially decrease the perceived risks and uncertainty. Hellofs and Jacobson (1999) found similar empirical evidence and they suggest that the products established market share can enhance the potential user's perception of the product utility. Hence, direct NE are related to a higher diffusion pattern of the certain innovation, (Sahay and Riley, 2003) and locking in users as the installed base increase offering more opportunities to utilize the technology and learn from peers (Pae and Hyun, 2002). In contrast, Tellis et al. (2009) reminds the consequences of "*chicken and egg paradox*" which can lead to a under adoption of new technologies. Hence, if the expected installed base of new innovation is causing uncertainties, potential end users will be reluctant to adopt the given product. This can

eventually lead to a under adoption and the installed base will remain insufficient. Therefore, the extrinsic value sources of direct NE may be delayed until a sufficient userbase is established and users are able to interact with each other (Ge, 2002).

Installed base

The trailblazers of NE, Katz and Shapiro (1992) states that *Installed base* effects, known as network externalities, can potentially build barriers for market entry with new products or technologies. In their research, Katz and Shapiro (1992) studied product introduction in a market with NE and how product compatibility affects adoption of the new technology. Basic presumption with NE products is that such markets exhibit *excess inertia* i.e. that customers are biased toward existing products. This presumption derives from the network characteristics that product users receives external benefits the more there is existing users of compatible products i.e. the bigger is the userbase of the selected technology. Farrell and Saloner (1986, p. 940) argue that "in the presence of compatibility benefits, a user who switches to a new, superior technology cannot obtain its full benefit unless other current users also switch and new users adopt the new technology". Thus, new innovations entering the markets can face the problem of *excess inertia,* which refers to a reluctancy to switch current systems into a superior new standard when important NE are present in the current technology (Farrell and Saloner, 1986; Katz and Shapiro, 1986). Katz and Shapiro (1994) further explain that the bias toward new technology might be caused by that the current users are somewhat tied to the old technology or the expected future userbase is causing uncertainties. Beside excess inertia, academics have distinguished concepts such as *lock-in* or *path dependence* to describe positive consumption externalities that may favor established inferior products over the newer, and even superior ones (Katz and Shapiro, 1994; Tellis et al., 2008). However, Katz and Shapiro (1986) argues that new product entry may be profitable even if it worsens industry performance by stranding customers who own the older technology and making them obsolete.

The commonly used strategy, when direct NE are present, is penetrate the markets to establish large installed base rather than skim marginal profits (Lee and O'Connor, 2003). Due to fierce systems competition and setting industry standards, 'locking-in' users is the de facto objective in short-term. Farrell and Saloner (1986) argues that when the product is utilizing NE and has sufficient installed base, the process is exceedingly difficult to reverse

due to high switching costs that restrain users from adopting new alternatives even if they are superior. Hence, the external utility that users gain from installed base is resultant from direct NE phenomenon and may have major influence on product decisions (Lee and O'Connor, 2003). For instance, Arthur (1989) argue that a technology which achieve head start in early adoption may eventually lockin the market of potential adopters. Thus, stranding other technologies and building entry barriers for new entrants even though they may be superior and outperform the predecessors. Further, in markets with potential direct NE, the product should reach critical mass of adopters that represents sufficient number of users in which the NE starts working and the rate of adoption takes off (Rogers, 1995). Consequently, Mahler and Rogers (1999) states that NE have important role to generate external value in certain product categories such as telecommunication services and where users are interacting with others.

Hence, supplying companies might face *start-up* difficulty early on the product lifecycle and during market entry. If the product value is solely based on the installed base of users, the new innovation may offer scarce value to early adopters at the time of product introduction because lack of other users in the network (Katz and Shapiro, 1986). *Excess inertia* can trigger the start-up problem where it prevents adoption of new innovations which can occur when first users are not willing to bear the over-proportional risk of being the first adopter of a standard (Weitzel et al., 2000). Consequently, markets with NE are often characterized by significantly high market uncertainty and innovation risk for product entries (Chakravarti and Xie, 2006). Therefore, when company is introducing a new product, it should be aware of the installed base effects and ensure sufficient supply of complementary goods to facilitate early trials and diffusion. Conversely, if the market and product is tipped toward current systems and gaining external value from the installed base, the technology may be "locked-out" (Schilling, 2002; Katz and Shapiro, 1986). Hence, large installed base extends the variety of user's utility in terms of user training of the particular technology and entice more complementary and compatible software developers (Choi, 1994).

Especially in industrial markets, early adopters invest in learning to use the technology and complementary products, which in turn lock them in and prevents defections to other available systems (Shapiro and Varian, 1998), thus increasing the capital and social switching costs. Typically, in system markets, and especially products with NE are

characterized by standards. Chakravarti and Xie (2002) argues that industries with standards can reduce uncertainty about the expectations of future size of userbase, thus induce early adopters of technology and stimulate the development of complementary network. Thereby the pioneer has the opportunity to set the standard while enticing users to its network and ensuring the long-term performance of the product (Srinivasan et al., 2004). Choi (1994) and Hill (1997) continues sufficient installed base (of focal product) can attract more software developers and compatible products increasing the utility of the product and thereby enhancing adoption of new innovation.

Conversely, NE can also create slowness factor in diffusion speed. According to Rogers (1995), due to slow initial diffusion of many innovations, the uncertainties associated with the potential utility of product increase when only few adopters exists. For instance, potential end users can adopt a wait-and-see attitude and delay their adoption decision until perceive product uncertainties are reduced (Farrell and Saloner, 1986). Further this wait-and-see attitude can cause friction in adoption, especially in systems market. Srinivasan et al. (2004) draw that hardware companies want to ensure the software and complementary firms to supply a wide selection of software, but they usually wait until the new hardware has enticed enough users before committing to the hardware platform. This *chicken-and-egg* coordination problem between hardware producers and software developers is not unexceptional (Gupta, Jain and Sawhney, 1999). Alternatively, in the absence of competitors and industry standards, the new technology can seize the opportunity. According to Srinivasan et al. (2004), in the absence of early competitors, the wider is the window of opportunity for the radical technology to exploit NE. Thus, the pioneer product can establish a large network, coordinate the development of complementary goods, and enhance the utility of its products to customers. Hence, when an industry is characterized by NE, a technology's installed base and the availability of complementary goods are major determinants in user adoption and therefore may be a critical factor in the initial product success in industrial markets.

Critical mass

According to Rogers (1995) and Wärneryd (1990), a crucial objective for a product supplier is to ensure sufficient pool of users. Before the technology is diffused among the target segments and reached critical mass, first users must rely on the intrinsic features of the new

innovation because the additional benefits of the NE remain uncertain for early adopters (Goldenberg et al., 2010). Therefore, adoption decisions are not only guided by a products current installed base but also by their expectations of the future size of the installed base (Sheremata, 1997). Consequently, Sheremata (1997) points out that in the context of NE, influencing potential adopter's expectations should be focused on company's marketing strategies.

As the current research denotes, the expected network size has impact on consumers adoption decisions until uncertainties are reduced (Ge, 2002). This might cause 'chilling effects' on market growth caused by the wait-and-see attitudes adopted by potential customers that derives from the scarce utility expectations from an innovation that has few existing adopters (Farrell and Saloner. 1986). Thus, this situation delays the positive direct NE and extrinsic value derived from network size until a sufficient userbase has developed that allows customers to interact with each other and utilize direct NE (Ge, 2002; Farrell and Saloner, 1986). According to Rogers (2003), the growth of network products may follow a two-stage process, that is, slow initial diffusion followed by a very rapid growth stage. To overcome this previously mentioned *start-up* situation and reduce perceived uncertainties associated toward the product, the availability of complementary products may enhance the adoption decisions by reducing adopters' uncertainty (Ge, 2002). Moreover, a firm can avoid the under adoption with a bundling strategy where the idea is to link the primary product with other compatible ancillary products which reinforces *positive feedback effect* and thereby increases demand for both (Shapiro and Varian, 1999). In their research Lee and O'Connor (2003) studied new product launch strategies for NE products. Yet the growth of the installed base is the first-priority performance objective in the short term, as it will stimulate the *positive feedback effects* and enable the NE product to lock-in a customer base. However, Lee and O'Connor (2003) conclude that the success of NE product depends on both, the intrinsic and extrinsic value, contrary to nonnetwork effects product. Once a NE product attracts a sufficient installed base becoming the dominant design in the market, it will lock-in users and thereby gain long a term success (Lee and O'Connor, 2003). In addition with the importance of the installed base, the system compatibility and complementary products are also critical sources to generate early utility for NE product. In the following chapter the concept of indirect NE will be discussed.

2.1.2 Indirect network effects

Katz and Shapiro (1986) explain that indirect network effects arise when the user's utility increases due to the supply of complementary products. Prior research has generally referred to the primary product as "hardware" and to any product complementing the primary product as "software" (Basu, Mazumbar and Raj, 2003). Thus, as the userbase of the hardware product increases, it will entice complementary product developers i.e. compatible software applications and service providers to enter markets. Sufficient supply of complementary products and services influence on the utility that customers derive from the focal product (Srinivasan et al., 2004) and this introduction of complementary goods generates the another extrinsic value source, indirect NE (Sheremata, 2004; Shocker et al. 2004).

Researchers have acknowledged various aspects of indirect NE, including; (1) coordination between hardware and software industries (Katz and Shapiro, 1994,1992), (2) standard-setting (Hill, 1997; Schilling, 2002; Farrell and Saloner, 1986), and (3) customers regarding the adoption of technology (Tellis et al., 2007; Molina-Castillo et al., 2011). Ge (2002) argues that the availability of complementary products may reduce the uncertainty of the initial product introduction with NE, decreasing the probability of start-up problem and consumer uncertainty toward the product. Also, a study conducted by Shocker et al. (2004) implies that although customers may experience problems evaluating the product itself, the presence of other compatible products may help their decision, as the final value of the combination will be higher than the value of the isolated product. In their study, Stremersch, Tellis, Franses, and Binken (2007) pointed out that researchers have observed that a critical mass of complementary products is required for the focal product to take off. In addition, Shurmer (1993) states that the number of adopters positively affect the indirect NE, since the market potential becomes increasingly attractive to organizations, hence induce them to develop and enter the markets with complementary products. Moreover, Lee and O'Connor (2003) illustrate that the more application software (an ancillary good) is available for an operating system (primary good), the greater is the total value for customers who use that operating system.

According to Hill (1997), the availability of compatible products is determined by the installed base of the given product. To support his argument, Hill (1997) gives example from personal computer markets. The battle between Wintel standard based on Microsoft's

Windows and an Intel microprocessor, and the alternative (incompatible) Apple standard built around Apple computer's Macintosh operating system and a Motorola microprocessor. Even though Apple was first to market, their installed base grew more slowly than the installed base of Wintel machines and therefore software developers wrote application programs for the bigger Wintel markets first. Since the availability of software applications for Wintel users grew, consumers placed increasingly greater value on them and resulted an increase in the installed base of Wintel machines. Hill (1997) argues that Wintel's victory on employing graphical user interfaces (GUIs) enabled it to establish itself as a technological standard in the personal computer markets. In addition, Kahan and Klausner (1997) argues that the value of NE increases to current or potential customers as their use becomes more widespread as a result of direct NE. Conversely, the enhanced value generated from indirect NE is extrinsic to the physical attributes of the product and is derived from the increased availability complementary products (Lee and O'Connor, 2003). Below in figure 6 is presented Hill's (1997) illustration of increasing returns in the personal computer industry enhanced by direct and indirect NE.

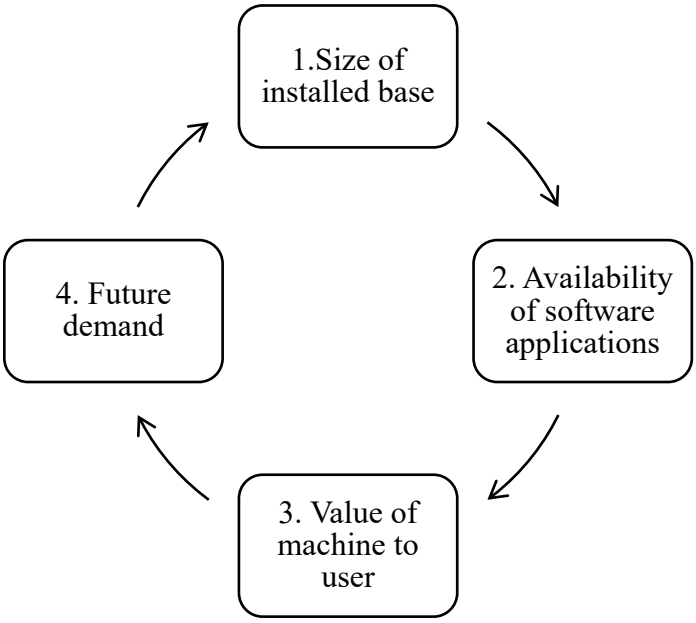

Figure 6. Increasing returns in the personal computer industry by Hill (1997).

In above picture, the interrelation of direct and indirect NE is presented and demonstrated how they affect each other generating a self-reinforcing character (Hill, 1997). As the figure 6 illustrates, a larger installed base works as an incentive for developers to supply compatible

software applications, which in turn has a positive impact on the value of a particular machine to users. Increased perceived value of the product leads to a greater demand for those machines, which translates into a greater installed base. The increasing returns is equivalent to positive feedback effects and is used to describe the self-reinforcement effect (Hill, 1997; Arthur, 1989). Hence, this self-reinforcement nature of systems might have major impact on the competitive dynamics in the markets and small changes in market dynamics might result one technology becoming standard (Arthur, 1989). Moreover, Choi (1994) argues that competing companies being "locked-out" can occur even when the dominant design is clearly inferior compared to other technologies in the market.

Podoynitsyna et al. (2013) suggest that especially for new technology ventures to bring out complementary products and services for its main product are typically not sufficient. Thus, the lack of complementary products from third parties are causing uncertainties to potential adopters thereby decreasing the probability of adoption. Therefore, new technology ventures may have to rely on other companies on markets, sometimes even competitors, to ensure the supply of complementary products and services to achieve critical mass and leverage indirect NE (Podoynitsyna et al. 2013). The system coordination is important issue when the focal hardware product needs complementary software to generate value. In order to ensure the proper coordination between systems, the concept of hardware/software paradigm is important to cover.

Hardware-software paradigm

Hardware/software paradigm denotes to system in which each user must acquire two components to generate benefits, like computer hardware and software (Katz and Shapiro, 1994). Thus, this hardware-software paradigm applies to many industries and arise compatibility issue. According to Katz and Shapiro (1994), when an individual or organization is considering to adopting a new durable hardware, they are also forming expectations about the availability of software. Hence, the availability of software will depend on what other consumers do, in other words how large is the installed base of hardware, which gives rise to positive feedback effects (Katz and Shapiro, 1994; Hill, 1997).

Katz and Shapiro (1994, p. 94) suggest that "in the presence of economies of scale in the production of software, the availability of software will depend on what other consumers do,

which gives rise to positive-feedback effects". This market characteristic might create a situation where users delay their decision until sufficient availability of software and content applications, thus avoiding the risk of adopting the "wrong" standard (Goldenberg et al., 2010). Hence, supplying hardware company must make strategic decision about how open or closed its system is. Like current theories suggest, the availability of software applications in the future is critical determinant in product adoption decisions. Next two, horizontal and vertical approaches for compatibility are presented. The objective of system compatibility can be distinguished as follows, to lock-in current users or unlock potential customers and further entice new software developers to enter the markets.

Compatibility

Farrell and Simcoe (2011) explain that the benefits of compatibility are twofold. They made a distinction between *horizontal* and *vertical* compatibility. The former denotes to the ability to share complements across multiple platforms in which its installed base of complements can be easily accessed for rival systems. For instance, many parts of the Internet are horizontally open and thus i.e. web pages can be displayed on different competing browsers. Hence horizontal compatibility enables benefits such as the ability to communicate with a larger installed base (direct NE), creates positive feedback between the size of an installed base and thus incentivizes the supply of complementary goods (indirect NE). The latter, vertical compatibility, "is the ability of those other than the platform sponsor to supply complements for the system" (Farrell and Simcoe, 2011, p. 5). For instance, other independent firms have the opportunity to supply complements without the permission of a platform leader. According to Farrell and Simcoe (2011), with vertical compatibility a platform leader may obtain multiple benefits: increased variety when vertical compatibility allows users to 'mix and match' components, reduce the cost of entry, strengthen competition in complementary markets and ultimately generate a modular system architecture and division of innovative labor. For example, many computing platforms use vertical openness to attract independent software developers. Both, horizontal and vertical system openness can be a matter of degree rather than a sharp distinction thus a platform leader may offer liberties in technical access policies against access fees. (Farrell and Simcoe, 2011)

However, even though the benefits of horizontal and vertical compatibility are often broadly shared, the process may generate conflict and coordination difficulties and thus advocates for technology standards exist. The presence of an installed base may be source of conflict where upgrading an installed base can be costly. Moreover, firms are typically 'tipped' toward standards to preserve their investments in existing designs. Further, platform leaders with a large installed base will support designs that preserve or increase switching costs whereas competitive entrants push to reduce them. Farrell and Simcoe (2011) explain that since compatibility often promotes entry and competition, firms are usually incentivized to standardize components that complement their proprietary technology thus leaving opportunity for differentiation in areas where they have a technical edge. (Farrell and Simcoe, 2011)

Katz and Shapiro (1986) states that the main question of compatibility is whether there is interoperability between different systems. The compatibility choice creates demand side economies of scale which make standardization a central issue in many industries (Farrell and Saloner, 1986). Indirect NE arise interest within researchers and practitioners because they have impact on the growth of software availability and hence hardware sales. (Podoynitsyna et al. 2013; Choi et al. 2009; Stremersch et all, 2007; Hill, 1997). This hardware/software interdependency was described in the figure 6 where the positive feedback effects in the system markets were demonstrated. Therefore, product compatibility is an important aspect of product design in many high-technology industries and especially in markets with NE (Farrell and Saloner, 1986; Katz and Shapiro, 1986; Hill, 1997). Wang et al. (2010) believe that company's decision about system compatibility or incompatibility is pivotal as NE markets tend to generate standard wars. Hence the compatibility choice in NE markets is important as the user's utility is derived from the availability of compatible goods and the supply of software applications whereas the availability of compatible products is determined by the userbase of the technology (Hill, 1997). The indirect NE literature commonly suggest that the availability of complementary products is a crucial factor when the customer is making decision between competing technologies (Choi, 1994), thus it has positive influence on the utility of the entire hardware-software system (Further, Church and Gandal, 1992).

The primary objective of compatibility is interoperability between complementary systems to achieve interchangeability (Katz and Shapiro, 1994). Thus, products with direct NE interchangeability refers to the interconnection between different networks whereas products with indirect NE interchangeability enables components to interoperate with other systems (Katz and Shapiro, 1994). In their research Wang et al. (2010) studied how the order of market entry and system compatibility may affect firm survival in markets with NE. They found that pioneers experience a survival disadvantage compared with early followers in NE markets, but the survival duration depends on the intensity of NE and compatibility choice. Thus, market pioneers face the unique installed base characteristic of NE markets. Therefore, the first mover is exposed to a start-up risk because of the zero or insufficient installed base at product introduction but in contrast provides a high first mover benefit to establish installed base to create entry barriers and competitive advantage (Wang et al. 2010).

The commonly accepted view in NE markets is that product performance and quality are not sufficient to satisfy user's expectations. Especially in systems markets, the hardware technology needs a variety of accompanying products, software applications, services, and processes to complement the focal product (Vowles et al., 2011). This full system infrastructure becomes more influential when the innovation is starting to shift from early users to mainstream markets (Moore, 1999). The transition can be achieved by establishing integrated network which reinforce the whole product user experience in the user network, comprising complements and producer network (Frambach, 1993). To make the primary good attractive for potential adopters the complements network includes compatible products and services to a given system (Lee and O'Connor, 2003; Katz and Shapiro, 1994). However, technological development causes concern and uncertainties about the complementary ecosystem around the primary good (John, Weiss and Dutta, 1999). Thus, the role of producer network is supplement the focal hardware and create products that are functionally equivalent to and compatible with the innovation, decreasing the level of uncertainty about the innovation (Vowles et al. 2011).

Indirect NE theory is important for new technology suppliers, as it can guide the company through the critical phases such as the market introduction and facilitate early adoption (David, 1995). David (1985) argues that suppliers and end users alike commit themselves relatively quickly to a few and manageable technical solutions. Thus, the variety of

alternatives are creating problems, uncertainties exists and hence, markets does not have resources to test all the available solutions (David, 1985) and eventually this may lead to inefficient market solution. Therefore, supplying hardware company can reduce the perceived product risk by ensuring horizontal or vertical compatibility with leading software vendors early in the product lifecycle. Next chapter is devoted to industrial diffusion process. Especially the role of early adopters (opinion leaders) and the role of NE to enhance the industrial diffusion process is on focus. The goal is to investigate the nature of industrial diffusion of high-technology products, how communication is utilized and how adopting organizations perceive the direct and indirect value sources.

2.2 Diffusion in industrial markets

2.2.1 Diffusion research

Since the diffusion theory was introduced into marketing discipline in the 1960s (e.g. Bass, 1969; Robertson, 1967), the field has sparked multidisciplinary research across industry and market boundaries. However, the diffusion research on how organizations adopt in B2B markets is considerably under established (Makkonen and Johnston, 2014). They suggest that one explanation might be the variety of directions and research streams adopted in the studies (Makkonen and Johnston, 2014). Thus, in B2B markets innovations and their implications should be viewed in the face of new production inputs, machines, processes, and techniques within organizations (Capon and Glazer, 1987).

Since technology adoption can significantly affect company's success in markets (Frambach, 1993), determine its competitiveness and survival (Stoneman and Kwon, 1996), and create competitive advantage (Wilson, 1986), it has become important issue in managing new innovations. Thus, as Hall and Khan (2003. p.1) noted in their research that "it is diffusion rather than invention or innovation that ultimately determines the pace of economic growth and the rate of change in productivity". Traditionally the research in the field have focused on end user benefits and costs of adoption (Hall and Khan, 2003) but more recently, the diffusion research has approached the topic from different perspectives and studied other factors to determine the demand of new technologies. Hence the research paradigm has shifted from end user perspective to supplying company perspective and analyzing new

streams such as availability of complementary products, the role of NE in industrial diffusion process and the supplier-end user relationship (Hall and Khan, 2003).

Woodside and Biemans (2005) defines the adoption as a decision-making process that ends up utilizing the innovation with the intention to use it now and in the future. Whereas the diffusion can be defined as a process by which something spreads (Robertson, 1971) or "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p. 5). Hence, the definitions and concepts are closely related in diffusion theory. Makkonen (2008) distinguish the concepts and argues that individual level adopting decisions are usually seen as "building blocks" of the aggregate rate of diffusion. Yet the ambiguous definitions and multidisciplinary approaches, the research in diffusion field has usually focused on enhancing understanding of the different factors such as behaviour patterns, interrelations, product complexity, switching costs, perceived complexity and traditional benefit/cost approach that 'explain' the adoption (see e.g. Vowles et al., 2011; Rogers, 2003; Kim and Srivastava, 1998; Mohr; 1982). Despite the various approaches adopted in perspectives and research objectives, diffusion is regarded mainly as information dissemination where we are affected by social influences in social context (Rogers, 2003; Montgomery, Lipshitz and Brehmer, 2005). The ultimate objective is to influence our expectations in a favorable way and reduce the risk and uncertainty within social context (Valente, 1995) and thus, diffusion of innovation can be seen as "a social process in which subjectively perceived information about a new idea is communicated" (Rogers, 2003, p. 17). In his seminal book, Rogers (2003) specified that innovation, communication channels, time and social system are elements identifiable in every diffusion process.

Understanding the current research stream and the various definitions of diffusion phenomena are essential to build a coherent context for the next chapters. In this research the social context constructs comprise the whole nascent industry and all the case company's network partners. Further, the communication channels are to be viewed from the early adopter's perspective, as they have been the first users of the case company's product. The case company have used their end users in product testimonials and other communicative purposes to disseminate information about the most advanced product in the markets to

reduce perceived risks and uncertainties. Next we are briefly covering the pre-diffusion phase to understand the dynamics of new high technology market entries in B2B markets.

2.2.2 Pre-diffusion phase

Regarding to Ortt (2010, p. 47), "the invention of new technological principles, their application in new product categories, and the subsequent diffusion of products based on these principles often result in an erratic process stretching out for decades". Thus, many organizations are involved in the process developing and introducing new high technology products in markets (Ortt, 2010). According to studies conducted by Tellis and Golder, (1996) and Olleros (1986), some of the pioneering companies eventually turn out to be very successful, but remarkably many of the companies are unable to reach product maturity in the markets.

Ortt (2010) studied the phases prior to large-scale production and diffusion which he used to refer as the pre-diffusion period. Ortt and Schoormans (2004) argues that typically the S-shaped diffusion curve invariably starts several years after the initial attempt to introduce versions of a specific product category in the market. Ortt (2010) argues that mainstream diffusion research seems to imply that large-scale diffusion starts directly after the market introduction of a new high-technology product. Therefore, the current literature and theories indicates that the large-scale diffusion can be represented by an S-shaped diffusion curve implying that the diffusion process is quite predictable (Ortt, 2010).

Depending on the school of researchers and the theory that is adopted, different factors and mechanisms are adopted to explain the delay between invention and large-scale diffusion (Ortt, 2010). The traditional diffusion approach explains the start and the rate of the diffusion by separating the adopters into different categories and investigating their perception of the innovation (Rogers, 2005). Rogers (2005) distinguishes patterns by separating the subsequent groups of adopters and product categories. Hence, this approach is focusing on the diffusion patterns determined by the demand side factors, neglecting the perspective of supplier's role developing the products and wider market environment affecting the initial diffusion rate (Ortt, 2010). Abernathy and Utterback (1978) offers an alternative approach to distinguish subsequent types of innovations that emerge in a certain industry. Their approach is especially applicable in a new industry where the focus is on major product

innovations at first but later on, when a dominant standard has appeared, the focus shifts product innovations toward process innovations. This industry and product evolution will fundamentally change the production and distribution chain rather than the product in question (Abernathy and Utterback, 1979). Abernathy and Utterback (1978) also stresses the importance of standards that the dominant product design will eventually develop. Thus, this dominant design is a configuration of components that represents the standard in the market for an extended period of time satisfying requirements and needs of a wide range of users (Abernathy and Utterback, 1978).

Ortt's (2010) study focuses on the time between invention and large-scale production and diffusion, also known as pre-diffusion phases for high-tech product categories. He distinguishes three phases in the pre-diffusion period, (1) invention, (2) first market introduction, and (3) the start of large-scale production and diffusion. Ortt (2010) defines the *invention* of a new high-technology product category as a first time that the technical principle of certain category is demonstrated and mastered. Whereas the *introduction* of product can be defined by the date at which the product is available for sales or can be transferred to users. Finally, the pre-diffusion period is separated from the standard diffusion process represented by the S-shaped diffusion curve by using three elements; a standard product or standard modules that can be produced and combined various ways but are based on the same standard platform. Secondly, a large-scale production unit with dedicated production lines and ultimately, diffusion of the product. Besides conducting the different pre-diffusion phases, Ortt (2010) assessed time interval in his illustration and added two subsequent phases. The innovation phase that comprise the time between invention to initial market introduction and the adaptation phase that include initial market introduction ending to industrial production and large-scale diffusion (Ortt, 2010). Below in figure 7, is presented Ortt's (2010) illustration of the pattern of development and diffusion of high-tech product categories including previously described pre-diffusion phases.

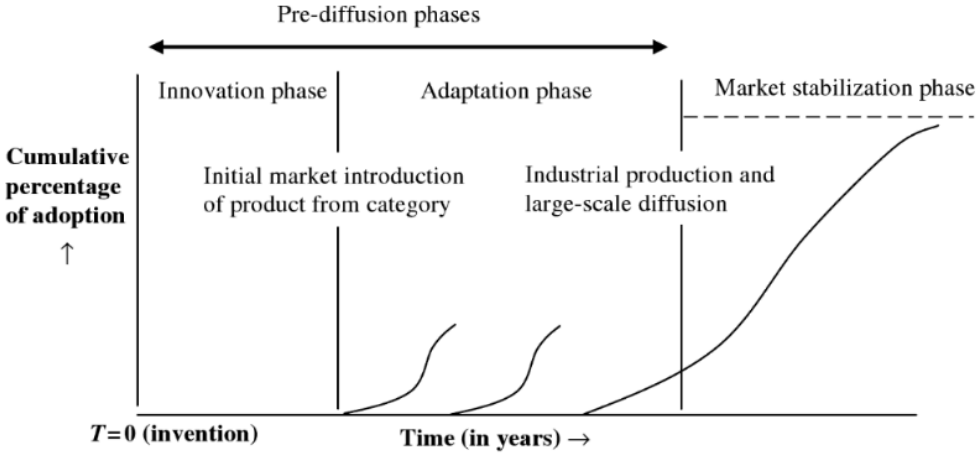

Figure 7. Pre-diffusion phase before initial take-off and market stabilization.

According to Frambach (1993), the research on the management of innovations has identified factors which determine the level of market performance of new products. The empirical findings in the field relate directly on the influence of pre-diffusion activities on adoption and diffusion processes and therefore should be connected to the diffusion theories (Frambach, 1993). In addition, Frambach (1993) identified eight factors that affect the adoption and diffusion of new innovation in B2B markets from suppliers' point of view. These variables affecting diffusion from the supplier's perspective are network participation, innovation characteristics and development, information -and information-process characteristics, adopter characteristics, competitive environment and marketing strategy.

2.2.3 Industry networks

In order to successfully introduce product in B2B markets, organizations should understand the pre-diffusion dynamics and ensure the support from industry network partners. The current literature suggests that there are many thresholds that the new innovation might be rejected due to switching costs, NE, and competitive pressure (McDade et al., 2002). Hence, creating superior value for clients and establishing collaboration with crucial industry partners can increase the probability to launch new products on the markets (Biemans, 2018). Commonly accepted approach for analyzing the buying behavior has focused on information gathering and information-processing activities (Moriarty and Spekman, 1984) and related

to need recognition, the evaluation of alternatives to meet the need, and finally buying the most suitable alternative (Nicosia and Wind, 1977). Organizational buying behavior (OBB) has been a classical subject in marketing discipline and it comprised studies which focused on investigating the phases of the buying processes and the factors affecting it (Robinson, Faris and Wind, 1967; Webster and Wind, 1972). Yet the vast studies conducted in the field in capturing the relationship between particular inputs and specific responses has been turned to difficult to conduct (Webster and Wind, 1972). Contrary to OBB approach, the direction in the research has transferred to study dyadic and multidyadic relationships in industrial markets (Håkansson, 1987; Andersson, Håkansson and Johanson, 1994). Halinen and Törnroos (1998) explains that the multidyadic, or network approach views organizations as being embedded in more wide and far-reaching business networks. Anderson et al. (1994) analyzes that organizations in B2B markets are in constant interaction with other identified counterparts, and that the interaction is affected by interdependence, prior experiences, and current expectations of other actors. Hence the studies in proving the link between industrial diffusion and network approaches is insufficiently established and true implications of the relationship are hard to distinguish.

Current industrial network approach suggest that a single adoption is an organizational activity in a broader relational setting comprising direct and indirect influences and interaction patterns between the industrial actors (Makkonen and Johnston, 2014). Thus, the adoption process ignites the adopter's established relationships with the supplier company, other organizations in the industry and potentially initiates new relationships within the markets (Makkonen and Johnston, 2014). Håkansson and Snehota (1995) interprets that in the context of established industrial relationships, the developed technical factors (such as activity links, resource ties), and social links (like attraction, trust, commitment) create bonds among the parties further shaping the mutual interaction and the resulting adoption. Hence, The established relationships within the industry network aggregate and are socially embedded structures that mediate the influence of direct and indirect undertaken by other network actors (Makkonen and Johnston, 2014). Consequently, this provides a dynamic environment for the adoption process as the network emerges and evolves as a result of these activities (Makkonen and Johnston, 2014; Anderson et al., 1994).

From the perspective of technology suppliers, Makkonen and Johnston (2014) highlights that organizations should seek a cooperative role and identify opportunities to become part of the customer's wider business model. Hence this collaborative approach addresses to comprise the actions, needs and structures that enable organizations to realize its mission and produce value (Makkonen and Johnston, 2014). In order to establish closer customer relationships and share common activities within industry network, the theory suggest supporting the development of social (trust and commitment) and technical (e.g. integrated information systems, joint relationship strategy) ties between customers (Makkonen and Johnston, 2014). However, diffusion in B2B markets is multidimensional and a multi-level process affected by intraorganizational buying/adoption processes and the general relational setting inside the entire industrial network of the adopting firm (Makkonen and Johnston, 2014).

In addition, Huhtala et al. (2014) outlines the active role of facilitators, intermediaries and adopters to overcome the barriers of adoption and facilitate successful diffusion of new products in industrial networks. Moreover, prior research generally confirms that the intensity of interactions, hence the relationship between the supplier and the buyer positively affects the speed and the rate of adoption (Frambach, 1993). Like discussed in the pre-diffusion part, the role of supplier-buyer relationship is important already in the product development phase and the collaboration in early product stage is more likely to positively affect the diffusion speed (Frambach, 1993). Further, supplying company can also affect the diffusion speed by proactively educating all the actors at the different stages of the industry value chain reducing the perceived risk and thus disseminate information about the value of their product (Schiavone and Simoni, 2019).

2.2.4 Product risk and uncertainty

Since high technology innovations in B2B markets are seldom plug-in solutions ready to be taken in use without process modifications, the initial implementation may include end user training and system tailoring and building (Robertson et al., 1996). Hence, the diffusion process in B2B markets is affected by many organizational, environmental and product related risks and uncertainties. These multifaceted risks are especially present with new high technology innovations.

High technology products are characterized with the tendency to make existing technologies obsolete while creating totally new markets and demand (Shanklin and Ryan, 1988). This special character of new high technology innovations is also causing problems in demand side and exposed to uncertainty and switching costs among the target segments (Shanklin and Ryan, 1988). The uncertainty is caused by the fast advancements in technologies (Norton and Bass, 1992; Heide and Weiss, 1995) and the lack of relevant prior experience by adopters (von Hippel, 1986). Beside technical capabilities, organizations face usually huge switching costs that delay potential adopters from purchasing a high technology product due to earlier commitments to legacy systems and products (Heide and Weiss, 1995). In addition to organizations technical capabilities and perceived switching costs, McDade et al. (2010), explain that traditional models of organizational buying behavior include individual characteristics, interpersonal factors and organizational buying process.

As discussed earlier, the purchasing process in industrial markets is multi-level and multidimensional affected by internal and external variables. To reduce the exposure to product and supplier risk, organizations apply intraorganizational trial across firm or specific units before initial adoption decision (Kim and Srivastava, 1998). Hence, Kim and Srivastava (1998) paid attention on intraorganizational diffusion process studying the diffusion of innovations within an organization. The urgency to underline the importance of intraorganizational diffusion emerged from the fact that sales of most technological products with business applications such as workstations and software programs to enterprises are based on additional purchases by the same organization (Wilson and Mummalaneni, 1986). Bettman (1973) argues that industrial purchase processes comprise a trial and comparison exercise where the buying organization receives a product prototype or purchases an innovation in small quantities to avoid technological risks related to the new supplier's products and services. Thus, the new innovation is properly evaluated and tested as part of organizations toolchains and processes before an initial adoption. Moreover, this evaluation period can substantially reduce the product risk as the organization has first-hand experience about the quality, proved the compatibility with their current systems and evaluated the vendor related switching cost (Weiss and Heide, 1993). Ultimately, the trial period can lead to a loyalty toward the new technology supplier.

Beside product risk and uncertainty, organization employees must accustom their knowhow and behaviour to learn and implement new innovations. Kim and Srivastava (1998) outlines that organization members can be reluctant toward change as they perceice high individual switching costs because they are less experienced in dealing with change. Conversely, organizations and buying units that are more open for risk taking are positively related to innovativeness (Kim and Srivastava, 1998). Hence, they suggest that risk-taking organizations are better in managing risks associated with the compatibility of the technology within organization and in utilizing the use of new technologies. Further, adequate education and training of employees can reduce the reluctancy for change and increasing the sensitivity "to keep up with the competition" can overcome the resistance to change (Kim and Srivastava, 1998).

Kim and Srivastava (1998) conclude in their research that selling companies can enhance intraorganizational diffusion by ensuring that products will be compatible with the existing values, habits and task environments of members of the buying organization and with existing technological systems. Collecting continuous feedback from customer companies regarding product compatibility, product performance in different tasks, exposing the product to as many members in the buying organizations as possible (e.g. on-site demonstrations or free, limited time site-licenses to encourage trials) and demonstrate the relative advantages of the product over the competing alternatives can reduce the individual thresholds in organizations (Kim and Srivastava, 1998). Further, supplying company can utilize intraorganizational diffusion by enhancing and supporting vendors through user training programs, and arrenging informal or formal information sharing events (Kim and Srivastava, 1998).

2.2.5 Opinion leaders

Individuals are in importance when speaking of adopting new innovations in B2B markets. Many supplying companies in high technology B2B markets face the same issue of how to facilitate the diffusion of new innovation and who to target early in the product lifecycle. Easingwood and Beard (1989) defines innovators as heavy users of the product category or the preceding technology and they perceive the new technology as a great opportunity. Hence, supplying company should identify these influential and innovative individuals inside their target markets.

The multidimensional process of diffusion in B2B markets is manifold. The diffusion process is affected by the engagement of opinion leaders and change agents, and different evaluation activities of the procurement unit inside the adopting organization (Makkonen and Johnston, 2014). Further, suppliers network partners can have positive direct or indirect influences on the adopter organization (Makkonen and Johnston, 2014). Strategical approaches for value creation in industrial markets include improving the NE of innovations (Parry and Kawakami, 2017; Greve and Seidel, 2015), collaborating with opinion leaders (Dearing, 2015), or implementing trade-marketing strategies with key stakeholders (Humphreys, 2010) to convince the enterprise markets about the quality and value of their new products.

Consequently, organizations adoption decisions are evaluated on continuous interactions among the buying organization, the selling organization and their industry environments (Kim and Srivastava, 1998). Hence, as "largely a theory of communication, diffusion research focuses strongly on information and communication channels and the way they are used to transmit information about innovations within social system and between the system and its environment" (Mahajan et al., 1990, p. 1). Hence, Makkonen and Johnston (2014) argues that supplying companies must first define the relevant unit of adoption, and to determine whether it is a single company or a dyad, or probably a value chain to effectively communicate about the new innovation. The role of opinion leader in industrial diffusion is largely attributed as an effective strategy to understand the characteristics of communication in industrial diffusion theory (Makkonen and Johnston, 2014). Opinion leadership refers to the degree to which an individual is able informally to influence other individuals' attitudes or change behavior in a desired way with relatively frequency (Makkonen and Johnston, 2014). In addition, Turnbull and Meenaghan (1980) suggests that opinion leaders' pivotal role in B2B diffusion theory may be based on their tendency for early product trials. As the theory of diffusion is based on communication, information sharing is one of the key objectives in effective innovation related communication. Thus, Frattini et al. (2014) suggest that early adopter can have significant effect on diffusion by disseminating information about the new product and facilitate the adoption of other companies. Moreover, opinion leaders share characteristics such as they are active information seekers (Schuman, 2002),

which leads to product knowledge (Hirschman, 1980) and with cumulated knowledge adopters are more aware of the benefits of radical innovations (Dewar and Dutton, 1986).

(Rogers, 2003) defines a product champion as charismatic individual who can have significant impact on supporting a new idea in an organization. Thus, his or her opinion behind an innovation can overcome resistance against the idea within the firm (Rogers, 2003). Marketing research suggest that niche targeting can be effective for innovative high technology products (Beard and Easingwood, 1996). Niche markets are narrowly targeted group that may seek a special combination of benefits for which they are willing to pay a premium (Lee and O'Connor, 2003). Thus, Beard and Easingwood (1996) stresses that targeting is essential tactic to reach the innovators early at the product life cycle, especially when the product is highly innovative and technically complex. Therefore, early adopter category is highly responsive to the benefits of a novel innovation and usually they are opinion leaders who has a positive influence on later adopters (Rogers, 2003; Beard and Easingwood, 1996). Consequently, Makkonen and Johnston (2014) points there are more available information regarding the potential benefits of the innovation to late adopters than to those who are among the first to adopt. According to Van de Ven (1986), supplying company's primary objective in marketing is consider how to trigger and reduce the action thresholds of individuals to appreciate and pay attention to new technologies, opportunities and benefits of the innovation.

Weiss and Heide (1993), suggest organizations with lack of prior related experience significantly increases the demand for information search and thus, organizations with existing knowledge are more likely to adopt a radical innovation (Fishman and Kemerer, 1997). Therefore, communicating about new innovations and improved product benefits should be targeted to innovators especially in high technology markets where the in-house knowledge and information processing requirement are high. Hence, prior related experience and innovation adoption is positively related in innovative organizations (Vowles et al., 2011). Hirschman (1980) points out that the organizations that are proactively searching for information about a particular innovation is a predominant factor in adoption, early adopters share this characteristic (Lee et al. 2002).

As a conclusion Vowles et al. (2011) suggest that innovative organizations have a person within the firm gathering support for the innovation as well as creating relationships with producers of the innovation. Hence, opinion leaders have important role in organizational product adoptions (Day, 1994) and they have the ability to sense and respond to new technologies with their knowledge within the adopting firm (Vowles et al., 2011). It is commonly agreed in the literature that marketers of high technology innovations in industrial markets tend to focus on identifying opinion leaders and concentrate customer education of early adopters (Beard and Easingwood, 1996). Therefore, the supplying company must be sensitive to acknowledge and understand the adopter's degree of innovativeness and technical capabilities to identify the earliest adopters to educate, inform and encourage them for trials (Vowles et al., 2011).

The diffusion chapter have focused on acknowledging the characteristics of industrial diffusion and phases in pre-diffusion process. As literature suggest, creating industry network relationships to ensure sufficient supply of compatible goods and software applications can significantly influence on product diffusion. Credible first users, industry network partners and the product quality are the main sources to decrease the perceive risk. Moreover, identifying organizations and 'opinion leaders' that are actively seeking information are more likely to try and implement new innovations. In order to reach these early adopters, the supplying company must accomplish credibility within the markets and establish trustworthy reputation. Effective communication and brand building can decrease the perceived product risk and uncertainty. Next we are analyzing industrial brand from the supplying company's perspective.

2.3 Industrial brand

Managers in B2B markets are not emphasizing branding and many of them are convinced that the phenomenon is confined to B2C markets (Kotler and Pfoertsch, 2007), or are somewhat skeptical about its benefits in industrial context (Leek and Christodoulides, 2011). Hence, their arguments often rely on the fact that they sell commodities or compete in specialty market where customers already know a great deal about their product offering as well as competitors. Moreover, brand loyalty is seen as a non-rational behavior that doesn't apply in the more rational B2B markets (Kotler and Pfoertsch, 2007). Industrial products and services are associated to be chosen after an objective and rational decision-making

process that includes for the so-called hard facts like quality/performance, benefits, price, and service leaving no room for emotional connections (Aaker and Joachimsthaler, 2000; Leek and Christodoulides, 2012).

According to the best global brands survey conducted by Interbrand (2019), eight B2B companies (IBM, Cisco, Oracle, SAP, Accenture, Adobe, Salesforce and Hewlett Packard) were amongst the top 100 brands in the world. Even though the percentage of B2B companies in the top 100 list is not astonishing, brands have the exact same purpose in B2B markets than they are serving in consumer markets (Kotler and Pfoertsch, 2007). The supplier's brand should be able to differentiate their products, services and businesses for competition (Anderson and Narus, 2004), hence it is effective channel to communicate the company's value proposition and benefits that their product or service delivers (Morrison, 2001). Webster and Keller (2004) note that the research and theoretical contributions of branding has mainly concentrated on B2C markets and therefore the need for empirical studies and managerial implications addressing branding within industrial context persist (Marquardt, Golicic and Davis, 2011; Leek and Christodoulides, 2012; Backhaus et al., 2011). Further studies of the concept of branding in industrial market is relevant for B2B marketers to successfully differentiate themselves by systematically managing company's brand in a highly competitive business environment (Herbst and Merz, 2011; Bendixen, Bukasa and Abratt, 2004: Kotler, 1991). Moreover, as Blackett (1998) underlines that brand is a sign of quality, origin, and performance to increase the perceived value and reducing the complexity and risk involved in the organizational buying decision.

Hutton (1997) studied brand equity in an organizational buying context and concluded that positive or negative associations are affecting e.g. in buyers' willingness to pay a premium, recommend it to peers, and give consideration to other company offerings. Hence, strong industrial brand image and reputation enhances to distinct product or service categories and has a positive influence on buying behaviour (Gordon, Calantone and di Benedetto, 1993; McEnally and de Chernatony, 1999), and ultimately, can be a determining factor in deciding between industrial purchase alternatives (Aaker, 1991). The tremendous importance of brand in B2C markets, the concept of branding and its different attributes has recently started to gain more attention in the B2B context (Leek and Christodoulides, 2012). Lately, academics have studied different approaches to B2B branding in various contexts such as B2B brand

equity (Kuhn, Alpert and Pope, 2008; Lindgreen, Beverland and Farrelly, 2010; Marquardt, 2013), internal B2B brand equity (Baumgarth and Schmidt, 2010), brand value and performance (Han and Sung, 2008), drivers of brand relevance in B2B markets (Backhaus, Steiner and Lügger, 2011), relationship quality as a driver of brand equity (Mudambi, 2002), and global brand leadership (Beverland, Napoli and Lindgreen, 2007).

More recently studies have focused on the benefits of branding from the supplier company perspective. These studies included that brand had positive effect on the perceived quality of the product (Cretu and Brodie, 2007), building a unique and a consistent product image (Michell, King and Reast, 2001), improve performance perceptions (Han and Sung, 2008), improve sales performance and profitability (Davis, Golicic and Marquardt, 2008), enhance competitive advantage (Michell et al., 2001) and using brand as an entry barrier for competitors (Michell et al., 2001). Industrial brand equity can also offer many intangible benefits to buyers; thus, it can increase the buyers' confidence in (Michell et al., 2001) and their satisfaction with their purchase decision (Low and Blois, 2002). More recently, marketers in industrial markets have increasingly shown attempts to exploit the potential of branding in B2B markets to remain distinct and build strong business relationships. In addition, extant research around the topic and academics in industrial marketing agree that supplying company's corporate and product brands are valuable resources that impact competitive position and advantage in B2B markets (Leek and Christodoulides, 2012; Arnett, Laverie and Wilcox, 2010; McDonald, de Chernatony and Harris, 2001). Moreover, B2B innovations also possesses associations and perceptions of value, but the ultimate awareness and product experience is created through product trials and contact with company salespeople (Gordon et al., 1993). It must be also noted that the company's distribution network partners are also particularly important to create coherent brand image through quality and value-adding services (Gordon et al., 1993).

Industrial brand reducing perceived risks

The traditional determinants in organizational buying behavior have been stressing the received benefits by the user and the cost of adoption. Usually, these benefits are approached by comparing the difference in profits when adopting organization is stranding the legacy system switching to new system (Hall and Khan, 2003). But this technological shift may include risk about the future benefits of new technology and lack of information creates

uncertainties. High technology systems, especially new immersive technologies, might require in-house capabilities like system know-how, modifications in workflows and switching costs that always takes time and thus slow down the adoption process (Rosenberg, 1972). Therefore, the purpose of brand development can serve as a signal that reduce buyer risk perceptions thorough quality and easy initialization (Leischnig and Enke, 2011). Beside lowering the risk perceptions of the product or service, brand can also serve in B2B contexts where complex systems require after-sales support and maintenance services (Mudambi, 2002).

The transaction volumes in industrial markets often involve high risk on the part of the buyer (Kuhn et al., 2008; Swait, Erdem, Louviere and Dubelaar, 1993) since the scale of the market transactions are typically substantial (Lynch and de Chernatony, 2007). Qualls and Puto (1989), and Schmitz (1995) argues that a strong industrial brand can minimize the perceived risk and help the selection of a right business partner. In their research to developing B2B brand personality scale, Herbst and Merz (2011) argue that B2B brands also fulfill a risk reduction function, and in order to do so, industrial brands need to establish trust. In contrast to traditional view of industrial buyers being rational constantly, empirical evidence proves that supplying company can develop trustworthy relationships by establishing emotional connections with their buyers (Bergstrom, Blumenthal and Crothers, 2002; Lynch and de Chernatony, 2007). Being able to establish trustworthy reputation and credibility among industry partners is especially important in new high technology ventures. The cost of adoption, reliability of delivery, technological know-how of the company and associated risks about the financial burden are present especially with new startups. Hence the supplying company should focus on developing intangible benefits that reduce the level of risk and uncertainty in buying organizations purchase decision (Mudambi, 2002). Hence, more recent studies in industrial makets have stressed the importance of establishing trust and developing affective as well as cognitive bonds with stakeholders similar to B2C markets (Andersen and Kumar, 2006; Lynch and de Chernatony, 2007).

Supplying company's efforts to differentiate company's product categories and establish trustworthy reputation might mitigate the associated risks among potential adopters because buyers are more likely to attribute value to brands in high-risk situations than they are in low-risk situations (Bennet, Härtel and McColl-Kennedy, 2005). This perceived risk

phenomenon is typically associated with the more complicated and higher cost purchases that are usually inherent within high technology industrial markets (Lynch and de Chernatony, 2007; Webster and Keller, 2004). Hence in high-risk buying situations industrial brands can reduce purchase risk, reduce information cost involved in decision making and ultimately evoke specific image effects (Backhaus et al., 2011). Consequently, they argued that the most important brand function in B2B markets is to reduce buyers risk related to purchase decision which might originate from the specifity of organizational buying behavior (Homburg, Klarmann and Schmitt, 2010). In addition to price and product quality, industrial brand has influence on many other intangible aspects of the company's offering (Mudambi, 2002).

In risk reducing context, beside product benefits in a category, brand relevance refers to the decision weight in initial product decision (Fischer, Völckner and Sattler, 2010). Fischer et al. 2010 explain that customers in high brand relevance categories should be more loyal toward the selected brand and exhibit higher willingness to pay (Fischer et al., 2010). Backhaus et al. (2011) notes that brand relevance relates to brand equity and therefore brands that influence decision making can be perceived as strong brands. In many cases in industrial markets, potential customers must usually turn to heuristics to make quality predictions because they cannot experience product quality in advance (Dawar and Parker, 1994). This incomplete information about product quality or alternatives further incentivizes to use decision heuristics in reducing the associated purchase risk (Backhaus et al., 2011). Thus, brand is a sign of many attributes (Blackett, 1998), and it can deliver high-quality indicator from an information perspective. Therefore, when buying organizations are building inferences based solely on brand information, the receiver assumes that supplier invest in branding and have strong incentive to maintain their quality in products and services (Backhaus et al., 2011).

Backhaus et al. (2011, p. 1083) concludes that "quality relates negatively to perceived performance risk relating to the argument that higher perceived quality may decrease the accompanying risk whether a product will perform its intended function". Van Riel, de Mortanges and Streukens (2005) suggest that strong brands in industrial markets reduce perceived functional risk of investing, and further, Cretu and Brodie (2007) argues that B2B brands are sources of trust and reputation from a buying company's perspective. Hence, trust

and reputation are valuable intangible assets especially when perceived purchase risk is higher in the specific product category (Nelson, 1970) or purchase situation (Backhaus et al. 2011). Moreover, current literature stresses that brands create confidence in decision making (e.g. Hoffler and Keller, 2003; Mudambi, 2002; Leek and Christodoulides, 2012) and thus, industrial companies can reduce perceived purchase risk and influence positively on customer decision making process by stressing their brands' risk-reducing functions and benefits (Backhaus et al., 2011). Consequently, in B2B markets where the perceived risks are usually high, the role of supplying brand is to reduce the perceived risk in purchase decision-making processes especially in systems markets where the vendor switching is also costly (Backhaus et al., 2011).

3 METHODOLOGY

The case company is a Finnish startup developing and manufacturing the most advanced mixed and virtual reality technologies for high-end professional users. Their high-resolution head-mounted display (HMD) is targeted to industrial users in verticals such as simulation and training, research, design, and engineering. Hence, the case company is competing in industrial markets, where current 2D -toolchains are dominating the industrial design and creative space. The case company improved current immersive technologies and brought their product to markets in 2019 and have since introduced new product generations of VR-2, VR-2 Pro and XR with see trough capability. Moreover, the case company have established many central collaborations with industry leading partners and gained to land remarkable end user organizations. The data sample used in this study is iterated in close collaboration with the case company's CMO and consist totally six interviews, four case company employees and two interviews from different end user organizations.

3.1 Research design

To explore, refine and develop further the NE theory in industrial markets and diffusion process, the research design must be adequate. This qualitative single-case study and proposed theoretical framework aims to explore and find possible interdependencies between NE and industrial product diffusion process. Next the research design and methods are discussed more in detail regarding chosen approach and how the data was collected and interpreted. Below in figure 8 is illustrated the "flow" of this research, from idea generation to research questions, framework identification and through research method to data analysis and new conceptual framework.

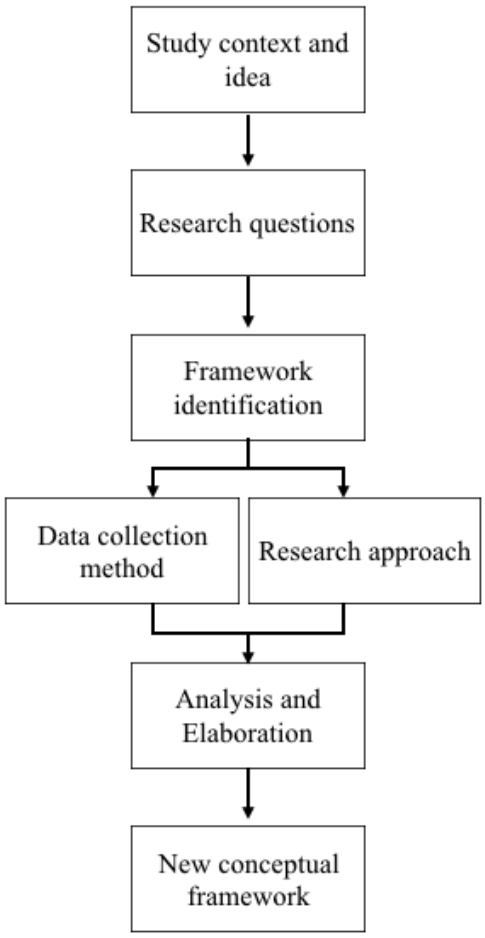

Figure 8. Illustration of the research design.

3.2 Research approach

This study on NE in industrial high-technology product diffusion follows a strategy that balances the inductive and deductive approaches. Dubois and Gadde (2002, p. 554) describe that "systematic combining is a process where theoretical framework, empirical fieldwork, and case analysis evolve simultaneously, and it is particularly useful for development of new theories". Systematic combining or abductive reasoning is a case study approach and it is based on two processes, first being matching theory and reality, while the second deals with direction and redirection (Dubois and Gadde, 2002). The premise of this approach is that these processes affect and are affected by four factors: what is going on in reality, available theories, the case that gradually evolves, and the analytical framework. Hence, their approach enables the researcher to continuously move between an empirical and model world. Therefore, systematic combining can influence the a priori research setting, thus

changing the research issues and analytical framework as the study proceeds to empirical world. (Dubois and Gadde, 2002).

Hence, when utilizing systematic approach, case study provides ideal ground for researcher to develop theory using in-depth empirical data of the empirical phenomena. However, case studies cause also restrictions and difficulties because the researcher might face challenges in handling the interrelatedness of the different concepts in the research Consequently, Dubois and Gadde (2002, p. 559) describe that it is typical in systematic combining approach that the issues evolves during the study and thus, "the original framework is successively modified, partly as a result of unanticipated empirical findings, but also of theoretical insights gained during the process". Hence, the preliminary analytical framework is based on researchers articulated preconceptions of the investigated phenomena. Therefore, the researcher's role is to modify the framework during the empirical analysis and data interpretation. (Dubois and Gadde, 2002)

Compared to other research approaches, the systematic combining enables the researcher to take more 'freedom' during the process, which is described as nonlinear, and path dependent. Even though the nature of the approach is constantly evolving and taking shape, the ultimate objective is to match the theory and observed reality. As the authors explain, systematic combining or abductive approach is positioned in relation to induction and deduction. In research domain, deductive approaches are concerned with developing propositions from current theory and make them testable in the real world whereas inductive approach stems from the grounded theory where theory is systemically generated from data (Dubois and Gadde, 2002). Yet, according to the authors, systematic combining is a closer relative to inductive approach as the continuous interplay between theory and empirical observation is stressed more heavily. Thus, this research is also inductive in nature as the research started from observation of the phenomenon then moving to searching for patterns. After observation the theory was develop based on explanations and conceptualizations-built form the data. Hence, the premise of inductive reasoning is to develop new meanings by analyzing the data rather that solely leaning on previous theories. Therefore, researcher's objective is to find relationships by developing empirical generalizations from the data analysis. Especially in case study analysis, the deployment of research questions is playing important role to gather relevant and analyzable data for the interpretation. Also, in this research, the a

priori framework derived from literature was modified during the empirical data was analyzed and new insights emerged from interviews. (Dubois and Gadde, 2002)

In conclusion, the objective of the systematic combining is to discover new things such as variables and other relationships of the studied phenomenon that have not yet been distinguished. Hence, the purpose is to supplement current theories with new findings rather than inventing totally new ones. Below in figure 9 are illustrated the guidelines that are used in systematic combining approach process. (Dubois and Gadde, 2002)

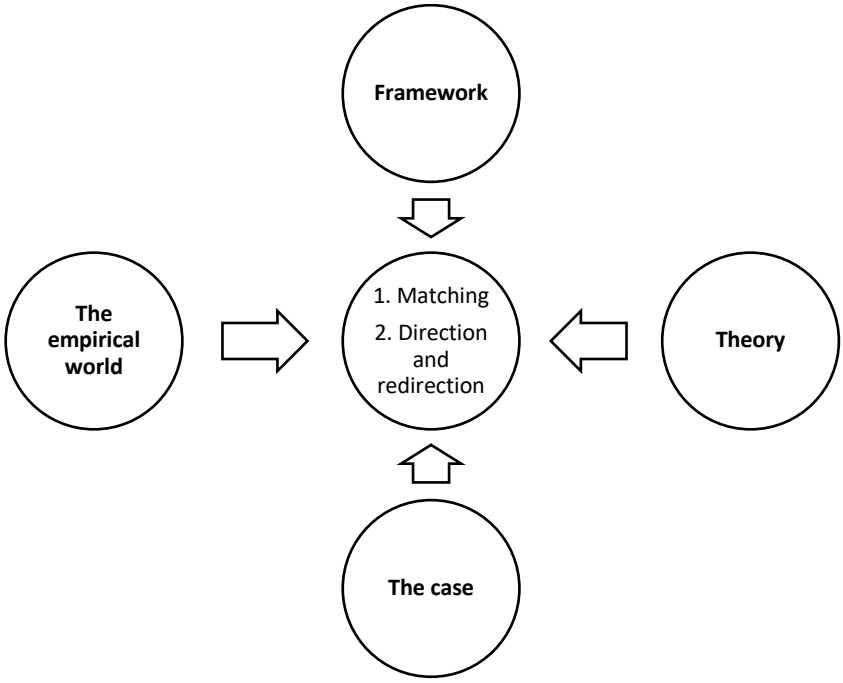

Figure 9. Systematic combining approach by Dubois and Gadde (2002).

The focus of this research is to study the interrelation of NE and product performance (diffusion) in B2B markets. Even though the current research is rather well established in many fields, the phenomenon has not achieved enough attention in industrial context. The a priori framework suggested that industrial networks are essential asset in new high-technology product introduction to ensure system compatibility and unlock potential end customers early on. Moreover, the role of early adopters (opinion leaders) is important channel for communication and building credibility, especially in a nascent industry like immersive technologies. Lastly, the industrial brand can substantially decrease the perceived

product/organization risk among early and potential adopters, and hence create credibility and enhance the diffusion of new innovations.

3.3 Research strategy

Woodside and Wilson (2003. p. 493) defines case study research (CSR) as "achieving a broad perspective in focusing on describing, understanding, predicting, and/or controlling the individual". According to (Eisenhardt, 1989), case study research allows the researcher to focus on understanding the dynamics that are present within single settings and enables holistic facilitation to understand the complex phenomena that do not separate easily from their contexts (Yin, 1989).

Cagnon (2010) explains that the main advantages of case research are its capability to produce an in-depth analysis of phenomena in context, support the development of historical perspectives and guarantee high internal validity, which is to say that the observed phenomena are authentic representations of reality. In other words, the case study is adaptable to both the context and researcher (Cagnon, 2010). Leedy and Ormrod (2001) agrees, that case studies attempt to learn from some intended objectives such as more in-depth knowhow about a little known or poorly understood situation. The case study structure, according to Creswell (1998), should be the problem, the context, the issues, and the lessons learned.

In addition, Hancock and Algozzine (2006) contributes that case study method can be used to build an in depth understanding about a phenomenon, hence, case studies are more descriptive in nature compared to other methods. Thus, qualitative case studies aim to examine chosen situation or event from the perspective of the person studied (Hancock and Algozzine, 2006). Further, Hancock and Algozzine (2006) explains that case studies aim to identify themes and categories of behaviour, thus case study research is usually more exploratory than confirmatory in nature. In contrast to quantitative research methods, where researcher try to test hypothesis or prove relationships between certain attributes, the aim of case studies is to identify themes and behavioral categories.

Yet, when utilizing the case study for research purposes, the method bears shortcomings (Cagnon, 2010). First, the method is time-consuming for both the researcher and the subjects.

Secondly, the external validity of the results is somewhat problematic because it is difficult for another researcher to reproduce a case study. Lastly, the case method has significant shortcomings when it comes to the generalizability of the results (Cagnon, 2010). Consequently, the probability that comparable studies will be conducted to generalize the theory inferred from the case study or to make the results applicable to an entire population is rather small. Therefore, in relation to Eisenhardt (1989), it must be noted that the result of a case study is, more often than not, an idiosyncratic theory, which is to say that it applies to a particular phenomenon or a specific process. Moreover, (Yin, 1994) argues that case studies provide little basis for scientific generalization.

According to Williams (2007) qualitative research involves purposeful use for describing, explaining, and interpreting collected data, thus it can be seen as less structured in description because it formulates and builds new theories (Leedy and Ormrod, 2001). In addition, Creswell (2003) explains that qualitative research can also be an effective model that occurs in a natural setting that enables the researcher to develop a level of detail from being highly involved in the actual experiences. Qualitative research builds its premises on inductive, rather than deductive reasoning, thus, it is from the observational elements that pose questions that the researcher attempts to explain (Williams, 2007). Hence, the strong correlation between the observer and the data is a marked difference in contrast to quantitative research, where the researcher is strictly outside of the phenomena studied (Williams, 2007).

In this research, the unit of analysis is industrial diffusion from NE perspective and single case study is adopted to enhance understanding about the utilization of NE in enterprise environment. Even though this study incorporates single case, the aim is to produce rich description and comparison between the supplier and end-user perspectives (Halinen and Törnroos, 2005).

3.4 Data collection

Following Wengraf's (2001) guidelines, the main data collection method was semi-structured interviewing, which provides the formality for analyzing complex phenomena, and allows the emergence of unexpected issues. The main questions were the same for all respondents, but some modifications and separate questions had to be made depending on

respondents' roles. The interviews included respondents from the case company employees and their clientele, hence depending on interviewee, adjustments were made to interview questions. Moreover, follow-up questions were asked on the emergent issues and themes to enable more in-depth data analysis and interpretations. All the questions covered the following aspects and themes to understand both perspectives, supplying company's and end users: 1) current state of immersive technologies; 2) barriers in adopting immersive technologies; 3) perceived product benefits; 4) the importance of product compatibility; 5) the value of product interconnectivity; 6) value of installed base; 7) the role of industrial brand.

All the research interviewees were acquired with the help of the case company CMO. We had discussions about the potential interviewee candidates and after the we agreed about the data sample, then all the informants were contacted via email. Majority of the interviews were held face-to-face in the case company's premises (4 out of 6), and therefore enabled suitable environment to investigate the nonverbal cues during interviews and attitudes behind the answers. This face-to-face setup was ideal to build personal connection with the interviewee and encourage them to describe some answers in more detail and elaborate their thoughts further. Due to geographical constraints, one of the interviews were conducted via MS Teams and one via telephone. Both interviewees hold major expertise in their respective fields and held strong background in immersive technologies.

Interviewees were conducted following a semi-structured method and the initial interview questions were reflected against the research framework and objectives. Consequently, following Gill's et al. (2008) guidelines, semi-structured interview method was chosen for the study in order to explore emerging responses, insights and themes in this rather broad context. Semi-structured interviews use theoretical framework or method as a structure that guides the interviewer to cover specific areas of interest. As Gill et al. (2008) and Keegan (2009) underlines that one of the major benefits of semi-structured interviews is the elaboration of information and the ability to discover motivations and beliefs behind the answers.

The interviews started with introductions of the participants and brief discussion about the topic. After the introductions, the interviewees were asked to describe their current position,

experience in the industry and position in the organization. Following the semi-structured interview method, interviewees were encouraged to answer and describe their experiences freely. The research framework and the objective of the interview questions worked as guiding tool to stay in the topic and avoid off the topic conversations. Before each interview, the participants permission to record the interviews were asked. The majority of the interviews lasted approximately one hour each and during the interviews, field notes were taken. After each interview, the conversation was transcribed and reflected on the field notes. The reflection and sorting of data after interviews was conducted to start the interpretation for the initial analysis of the study. The transcribed data from each interview was in easily accessible and analyzable form. This enabled further analysis and adjustments for the interview questions to get more insights from the selected themes. Hence, the analysis of data was an iterative process that started after the first interview and continued through the whole research process. After adjustments were done in the research questions, the clear patterns started to emerge, and new relevant data wasn't obtained anymore.

3.5 Data analysis

Analyzing data is the heart of interpreting and building theories from case studies (Eisenhardt, 1989). One commonly applied method in case studies is *within-case* analysis, which helps the researcher become familiar with each case as a stand-alone entity. Thus, this approach allows the unique patterns of each case to emerge before utilizing *cross-case* search for patterns (Eisenhardt, 1989). Tactics for interpreting and analyzing the available data is to select categories or dimensions, and then look for within-group similarities coupled with intergroup differences. In addition, searching for possible similarities or differences between cases is a fertile strategy to exploit in theory development (Eisenhardt, 1989).

This study combines the systematic combining and inductive approach, thus the data analysis is a mixture of both approaches. Glaser (1978) explain that data should not be forced to fit preconceived or preexistent categories, asserting rather that the categories are to be developed from data. Hence, the matching in systematic combining stresses the importance of going back and forth between framework, data sources, and analysis (Dubois and Gadde, 2002). This enables different categories, theories and constructs to emerge during the research process. All the data is analyzed and interpreted using guidelines by Eisenhardt's

(1989) and Dubois and Gadde's (2002) previously discussed approaches. Moreover, Nvivo software was used for interpreting empirical data to find emerging concepts and ideas.

To follow the guidelines suggested by the authors, the literature review was used in selecting the dimensions that emerged during the data collecting and analysis process. First, all the units were studied as stand-alone entities to gain understanding of their incentives and objectives. Then, categories that emerged from the research concepts during interviews were selected and utilized in cross-case analysis. These categories were further coded in Nvivo software tool to make better interpretations of the relationships. Cross-case analysis enabled deeper and richer comparison between units of analysis as the sample included four persons from the case company and two different end-user organizations. The following dimensions and sub-categories emerged during analyzing the empirical data in Nvivo process tool. Open and focused nodes can be further investigated in the appendix 4.

(1) Compatibility: Current software compatibility, switching costs, system integration
(2) Purchasing criteria: benefit/value, internal reviews (top management)
(3) Installed base: future benefits, intraorganizational use, collaboration
(4) Brand: trust, credibility (product/organization), future proofing and co-branding.

3.6 Reliability and validity of the research

Like any exploratory qualitative research, this study has some inherent limitations related to reliability, validity and generalizability of the results. Next these shortcomings are discussed briefly to offer guidelines for the reader and to guide future research.

3.6.1 Reliability

As Cagnon (2010) explains that the external validity of the qualitative case study results is somewhat problematic issue because it is difficult for another researcher to reproduce a case study. Hence, the research might suffer from lack of consistency as it is usually hard to repeat the data collection procedures with same results. The reliability of qualitative study is therefore somewhat complex to ensure and always depended on the context and reader.

3.6.2 Validity

Research validity in qualitative studies is usually related to whether the intended object of measurement actually is measured (Stenbacka, 2001). To assess the quality of a research, one option is to observe the generalizability of the research which can be done by testing the validity of trustworthiness of the research (Golafshani, 2003). Golafshani (2003) suggest that triangulation can increase the trustworthiness of the study by implementing different methods, multiple data sources and analysis techniques when studying the phenomenon.

In this research the issues with reliability and validity have been acknowledged. The study aims to provide a data set that is collected and interpreted to attain trustworthiness. Even though the research context is limited to cover the case company and their current clientele, the results hopefully contribute more broadly in the field. Further, the study was conducted in a nascent industry that is developing constantly and currently case company's product is not technically ready to be connected with another HMD's. The primary data source in this research was obtained through semi-structured interviews but supplemented with informal discussions with case company employees. Hence, one obvious limiting factor in relating to this research is the lack of observational data that totally included six interviews (4 case company employees and two end user organizations). Moreover, all the interviewed end-user organizations have more or less close relationships with the case company, hence this might have affected positively in their answers.

4 RESULTS

In this chapter the empirical results of the study are presented. The qualitative interview findings are interpreted in relation to the research questions. The sample group consisted total 6 interviewees, 4 case company employees and 2 end user organization representatives. The proposed framework in this research combined constructs to study new high technology product diffusion in industrial markets enhanced by NE. This phenomenon is approached by studying the linkages between product features and market characteristics. Further, B2B brand is studied as source of credibility and trust, thus decreasing perceived product risk of buyer organizations.

4.1 The characteristics of network effects in B2B markets

The first research addresses the market environment and characteristics of NE in B2B markets. The purpose is to evaluate the empirical result and compare them to the main theories comprised in the framework. Further, the concepts of intrinsic and extrinsic value are distinguished to evaluate product's functional and "networked" role in organizational adoption decisions. Hence, the aim is to understand are NE present in their target markets and can they accelerate the diffusion of their VR/XR HMD's product.

The first research question is approached by analyzing the current state of the immersive technologies in B2B markets. The overall development and advancement of the industry gives perspective to analyze the current thresholds in the diffusion process. During the interviews, it became evident that depending on industry verticals, company capabilities and technological know-how varied significantly. Therefore, identifying early adopters or 'innovator' organizations is crucial for the supplying company to successfully introduce new innovations to markets and ensure early product trials. Moreover, early adopters can have a double role in diffusion; they are an important adopter group, and they work as product advocates disseminating information about the new innovation. Lastly, the two value domains of NE product, direct and indirect, are discussed in the context of industrial diffusion.

4.1.1 Development of the immersive industry

Recent advancements in technologies, increasing interoperability between devices and Moore's law are enhancing the utilization of immersive technologies in enterprise environment. Even though the immersive technologies have been around for a while, the technology has lacked quality capabilities to be utilized in professional use. The insufficient quality of the devices has been so far the biggest barrier in professional use and adoption. Hence, the relative underdevelopment of the systems to be used in industrial immersive computing was the reason behind case company's founding. Moreover, any frontier technology is also dependent on the overall technology advancement of particular industry. For instance, computing power, graphics processing units (GPU's), central processing units (CPU's), and ancillary IT-infrastructure must be in place to run the HDM. Even though the technical requirements to run the HMD are quite easy to match, some organizations still perceive the technology complex and even too advanced. Hence, the case company has identified industry verticals that are more advanced in their technical capabilities to utilize, innovate, and adopt new frontier technologies. During the interviews, it became apparent that the first users of the technology hold previous experience of immersive technologies and hence, they are the ones that acknowledge the huge difference in the performance compared to predecessors.

"We know that people who are most excited about our product offering are the people who have the most experience in VR"
CMO of the case company

The knowledge, previous experiences, innovative organization culture, and in-house technical capabilities to implement immersive technologies were acknowledged as thresholds for adopting the technology. Since the adoption of immersive technologies varies significantly within different industries and organizations, the case company has determined their target customers by verticals and more particularly to workflows or use cases such as *training and simulation*, *design* and *research*. For instance, training and simulation industry is very advanced in utilizing immersive technologies in their respective field. But in contrast, architecture, engineering and construction (AEC) industry is rather hesitant to change their current workflows and shift to more digitalized workflows. Thus, the industry is still leaning

on legacy systems such as traditional pen and paper, and 2D toolchains. Even though the industry has showed enormous curiosity toward the technology, they are still reluctant to change and adapt their methods in immersive space. These thresholds may include perceptions of the complexity of the technology, lack of technical capabilities and individual level reluctancy toward chance.

While the product performance and value adding utilities are major determinants in organization adoption decision, the emerging industry and its 'infrastructure' are also affecting the future expectations of the industry as a whole. Hence, the case company employees and professional immersive technology users are expecting advancements in the industry as a whole. These future expectations are also familiar from the literature, and according to Katz and Shapiro (1994, p. 93), "rational buyers must form expectations about availability, price, and quality of components that they will be buying in the future." In contrast, the case company COO stated that "*companies in a nascent immersive computing industry are still operating in non-standardized environment*" where the system coordination between industry companies is still rather confined. However, the case company employees along with their clients are expecting that standard platform will emerge, and it is expected to be called as Open XR. Common system standard would be beneficial for all the hardware, software and complementary good developers in the industry. Industry standard could potentially prevent standard wars that are typical in systems markets, create structure, predictability, and thus increase the overall utility of the industry. Consequently, system standards enable different hardware and software applications to interoperate, increase the overall value, create bigger markets and prevent some users to be locked-in only to one system architecture. However, as one case company employee noted that B2B markets are seldom if ever a winner takes all markets. This is because enterprises don't want to be locked-in to a one particular solution which could expose them to a high risk in continuity and technological risk. In contrast to B2B markets, B2C markets are sometimes dominated solely by a few prominent providers, thus this kind of market 'domination' is rare in industrial markets. Hence, industrial markets are fragmented vertically and horizontally into markets where standard systems are rarely born and dominated by a single provider.

"Overall value of any technology increases the more interoperability there is between different players in that industry, that is why standards are being created. So, when you are in a nascent industry, typically you are operating in non-standardized environment where you have multiple companies doing their own things." – COO – Case company

However, standard product designs would be beneficial and enable efficient coordination of the future development of hardware/software systems in immersive markets. Common system standard, with well-defined design rules and standard product solutions would increase the overall value of systems and decrease the perceived technology uncertainty. Thus, these design rules would decrease the obstacles in adoption, especially with the verticals that are not technologically advanced and perceive implementing new technologies too complex. According to the interviews, the interoperability between hardware and software systems are crucial to create value for the end user. Especially the case company employees stressed the fact that the hardware alone does not create any productivity gain, cost savings or creativity addition in organizations. The value is always created combining the hardware and software tools. Thus, the hardware suppliers in the immersive computing industry are dependent on the current and future software developers that enable the full deployment of the HMD device. Therefore, common design rules along with technological progress would further feed the rational expectations of customers to predict the market outcome (Katz and Shapiro, 1994). These expectations are adopted from the NE theory, and as the user base of the hardware system increases, it will make the whole industry more attractive for current software developers to consider system integrations. However, according to the interviews, current leading CAD ventures and other software tool developers hold magnificent negotiation power whether they would allow their software to interoperate with the new hardware tool. Consequently, the case company faces issues regarding the availability of compatible software tools. Interviews suggest that one possible solution to this problem is updates to current software tools or plugins that would enable immersive computing to interoperate with existing 2D toolchains. This system compatibility and availability of useful software tools was perceived crucial in the end user organizations. During the intervies it became apparent that adopting organizations have invested lot of money and time in their current workflow infrastructures. Hence, organizations legacy

systems and workflows are modified to support their specific needs. This is due to the fact that organization needs are rather heterogenous, and new system integrations usually involve customization in terms of hardware and software updates.

Along with system interoperability and standardization, the interviews stressed that development of computing and advancements in technologies are driving the value creation in the immersive computing industry. The development of cloud and edge computing will transform the current methods in data processing, processing power and graphics quality. Moreover, interviewees stressed that issues such as data privacy and regulations will probably emerge in the future. This is due to the fact that companies are designing and developing their future products in the HMD device and hence, data protection is a major issue for organizations. In addition, the development of 5G networks and other wireless data processing networks will offer opportunities to develop the hardware to wireless system. Hence, the overall development of technologies and design rules are further driving the opportunities to implement immersive technologies. However, like with many other technologies, we cannot predict all the potential values and implications of the technology.

As the interviews suggest, B2B markets are seldom biased toward one dominant system. Instead the markets are fragmented into multiple vertically and horizontally oriented suppliers. According to interviews, this market fragmentation is typical in industrial markets as organizations are minimizing their risks and dependency on one system provider only. To study the potential NE in industrial markets, the sources of product value offers an interesting perspective to observe the phenomenon within the industrial context. As the literature (e.g. Lee and O'Connor, 2003) suggests, product's intrinsic value is determined by its features and attributes designed into the product itself. Thus, the functional quality and performance are the source of the product's intrinsic value experience. In contrast, *extrinsic* value is unique for NE products, and derives from the size of the user base and available software and complementary goods. Whereas intrinsic value is constant, extrinsic value can grow 'exponentially' enhanced by direct and indirect NE (see e.g., Lee and O'Connor, 2003; Katz and Shapiro, 1994). Based on the interviews, intrinsic and extrinsic product values are present in B2B markets but the determinant factor in trial and adoption decisions is the intrinsic product value. In the following chapters, the NE are evaluated from direct and indirect value perspectives.

4.1.2 Direct NE

The common question in NE literature is that whether there is a bias toward existing products or systems over newer (Katz and Shapiro, 1992). The authors relate to the situation called as excess inertia where the markets are biased toward legacy system even though there are alternative, superior systems available. Hence, when companies are introducing new innovations, the supplying company face the problem of lack of installed base even if the product is superior to its predecessors.

It is commonly agreed among scholars (e.g. Farrell and Saloner, 1986; Katz and Shapiro, 1994) that direct NE derives from the installed base of the product. Hence, the utility of any user increases as new user adopt the same product and enlarges the network. Therefore, in the simplest form, there is a positive correlation between the number of users and the utility derived from deploying the same product. The interviewees recognized various future "consumption externalities" as the installed base of immersive technologies increase. From the case company perspective, the key value drivers could be categorized in two sources. First driver is the previously discussed industry development. Thus, as the common standard is expected to emerge in the future, it will create synergy advances in the industry. Moreover, if the standard is adopted by the key players in the industry, this would in turn create more positive feedback effects in terms of system interoperability and overall utility. Secondly, the development of computing as a whole and hence improved organizational technical capabilities will create positive value drivers to further facilitate the growth of installed base. These technological and industrial drivers can enable the case company to expand their offering, and create new service offering as the sales of their hardware solution accelerates. For instance, the case company has developed their own software application called *Workspace* to improve their product utilities and would further complement the software tool availability in the markets.

From the end user perspective, the future utility expectations regarding the installed base were quite similar. Company A representative said that they are able to decrease their costs and improve their production times as more people become captive with immersive technologies. In addition, he added that with the technology, they are able to increase cooperation with their partners and decrease travelling. Company B representative shared

similar thoughts about the future benefits. First, in a short-term, enterprise users must become more used to immersive technologies in their daily work environment. In order this shift to happen, he addressed that the technology must become more wearable and hence everyday tool in workflows. But most importantly, the case company employees and both end user organizations stressed the need for quality content and applicable software tools. These key drivers were seen as predominant in the shift from 2D toolchains to 3D immersive environment. Hence, the advanced technological capabilities would further enable the organizations to share content in virtual collaborative spaces. To facilitate this transformation from 2D screens to 3D immersive spaces, Company A representative noted that the only way to understand the future opportunities is to go step-by-step forward and push the boundaries within industries.

"We don't really know today, what are the most important applications of the future" – Senior technical lead, Company A

Hence, interviews suggest that this value shift from the present physical 2D screens into immersive 3D synthetic environments are driven by advancements in computing and emerging industry standards. Especially in a nascent immersive industry, where organizations are operating in non-standardized environment, the objective of maximizing the installed base rapidly is exceedingly difficult task. In contrast to B2C markets, organizations are facing enormous switching costs, technical risks, incompatibility risk and other factors related to their current task environments. Consequently, the case company employee explained that B2B markets are seldom if ever a winner takes all businesses. This is related to the previously mentioned factors that enterprises don't want to be locked into a particular solution. Being depended on one system provider would expose the buying company to a huge risk in continuity and technical safety. Therefore, both A and B Companies stated that their initial adoption was based on thorough product trial and evaluations. Both companies deployed the VR/XR device inside their companies within internal units. These internal units were "incubator" type of labs that try and evaluate new kinds of technologies that could be potentially later adopted inside the mother company.

These internal product experiments enabled the companies to evaluate the HMD device without risking their current production or research activities.

To establish wide market reach and penetrate the identified target verticals fast, the case company's go-to-market strategy was based on geographically and vertically focused land and expand. According to interviews with case company employees, this strategy focused on defined and selected partners. The partner selection, for instance with software developers, was based on their current clientele. The software partners ability to unlock potential end customers for the case company was perceived as the most important thing in the partner selection. Hence, the more current enterprise users the software company or value-added reseller is serving, the more interesting they are for the case company. In contrast to the partners ability to unlock defined key industry verticals, they are also a source to establish credibility from the case company perspective. Therefore, leading software companies, end user organizations, and value-added resellers establish credibility through partnerships and collaboration. This was also perceived really important. As one case company employee explained, their value proposition must be on the level that the biggest companies in the world can trust them. Thus, this credibility and trustworthiness must be earned through the quality of their product but also by establishing partnerships with leading organizations in the industry. Moreover, these early partners and early users served important role in the product development in a way that they offered feedback from the prototypes that the case company send them.

From the end user perspective, both client organizations A and B stressed the importance of trust and credibility when starting collaborations. But the predominant factor and initial decision behind the adoption is based on functional benefits of the new technology. Hence, the new innovation must be a major technical step-up in the defined areas. Both Companies A and B underlined that the product quality and performance in dedicated use cases is the most important factor to try and implement new technologies. Beside technical aspects and product quality, Companies A and B shared similar thoughts about the other key drivers to start collaboration. Company B representative stated that they have had bad previous experiences with companies in the past. Thus, these companies were not able to deliver their value propositions. Therefore, Company B perceived that the supplying company must show signs of future proofing and hence ensure that the company have came to stay. In contrast,

Company A shared similar reasons for collaboration but added that the case company was very open, transparent, and had innovative mindset. In addition, he further added that sharing similar values and company culture is also a critical factor in collaborations.

In addition to unlock key verticals through selected partners and collaborations, desirable future product features raised during the interviews. A central factor with all the interviewees were the HMD's future ability to be interconnected with other HMD's. This product feature was perceived as a key driver in the future enterprise usage to increase virtual collaborations, for instance in internal design reviews and virtual meetings. Thus, the case company employees and their clients recognized many utilities and opportunities as this feature becomes available. Currently, only the person who is using the HMD is fully immersed in the virtual or mixed virtual environment. Other team members in the same room can see the design or object on the TV screen but cannot interact with the synthetic objects at the same time as the user. Company A representative said that so far this has not been a problem because the technology has not been deployed in a mass scale. But however, he added that their organization is seeing VR and XR as a natural extension of everything today. Hence, the "single" user and isolation of others is causing issues, thus constraining collaborative virtual experiences. He explained that they are expecting multiuser immersive experiences in the future, especially with design reviews but also, for instance, remote virtual meetings with their branches in other countries. Client Company B shared similar expectations about the future product features in multiuser cases. He added that currently their organization is struggling with feedback and input issues in internal reviews. Moreover, both A and B companies stated that they have had situations where their teams presented designs and work progress for top management. These situations caused problems in deciding who to show first the project, hence isolating others from the experience.

The case company has acknowledged the need for horizontal interoperability. Interviews suggest that as the nature of work in B2B markets are based on collaboration, the need to create multiuser scenarios was perceived really important inside the case company. For instance, the case company has started to develop capabilities that will enable remote virtual meetings and increase the collaboration within and between enterprise units. Hence, the virtual multiuser reviews and other applications of collaborative work inside organizations was perceived really important with all the case company employees. Enabling these future

virtual collaborations to happen, the third-party software developers and other complementary good producers should be also incentivized to develop the capabilities.

In conclusion, in a nascent immersive industry direct NE are expected to increase the utility in the future. The installed base of VR and XR technologies are affected by the development of technologies, advancements in computing, and emerging system standards. Therefore, these key factors will drive the transformation from 2D screens to 3D immersive environments. Beside industrial and organizational factors, the availability of complementary technologies and software applications are also creating positive signals for later adopters. However, it could be said that the current 2D tools and CAD software's are enjoying the benefits of installed base effects. The diffusion of new innovations is usually gradual in B2B markets, as the buying process is affected by many factors and organizations are relying on their legacy systems to minimize all risks. However, the horizontal integration of HMD's that would enable the multiuser scenarios was perceived really promising during the interviews. The reciprocity between users could enable to give feedback and input during the immersive experience.

4.1.3 Indirect NE

As discussed in the literature, indirect NE are dependent on the number of available software and complementary products. The conducted interviews suggest that beside novel product quality, the compatibility and integration with current workflows was a predominant factor among the case company and end user organizations. This vertical integration with leading software and other partner companies to ensure the product compatibility was the case company's strategy entice early users.

The case company saw that product compatibility is a source of competitiveness. Like discussed previously, their strategy was to unlock key industry verticals through compatibility and partnerships. Hence, vertical compatibility was their strategical choice when the company entered to markets. The core was to ensure vertical compatibility through selected partners to establish large base of potential customers and hence gain credibility with well-known partnerships. Interviews suggest that especially compatibility with leading software vendors was the main target to penetrate markets. Therefore, the case company acknowledged the hardware/software paradigm and instead of waiting that their hardware

sales entice software developers, the company went to software developers first. In addition to system compatibility in opening the enterprise users in the target markets, one case company employee stressed that compatibility lowers the entry barriers. He explained that the barrier to adoption must be as low as possible by making the systems as easy to take into use and get started with. Moreover, the case company has to motivate the software companies to ensure the interoperability of the systems. Therefore, he added that in B2B markets, you need to do two sales at the same time. You need to sell to the ultimate end-customer, and also sell to their software vendor at the same time. Thus, ultimately the case company has to entice both parties on the program in order to proceed to future sales. Therefore, from the case company's perspective, growing the potential end-customer base is critical through vertical interoperability with leading software vendors. The interviews with the case company employees points that support from software vendors and value-added resellers is a key strategy to ensure the availability of software and complementary hardware goods. Further, in high technology enterprise markets the processes and workflows are complex systems, and hence value is in complexity.

Company A employee stated that system compatibility is really important. He explained that their company is processing enormous amount of data and updated daily. Therefore, the processes and pipelines must be up to date constantly. Any slack or delay in the pipeline would cause major problems. The company stressed that all new technologies that they test and implement, should be compatible with their current infrastructure. Recently the company has also shifted to handle high-end rendering internally in their workflow to support new technologies and ease the future integrations. In addition, the interview with Company A suggest that organizations face more problems when they have to implement new software. As both company A and B representatives stated, hardware systems are easier to implement but new software requires always more time and money. Company B representative shared similar thoughts about the system compatibility. Their organization are evaluating how easily the new hardware can be integrated into their current systems. In addition, they are considering do they have learn new software when deploying the technology in their workflows. Thus, both companies that product compatibility with company's current workflows in predominant factor in decision making.

Based on the interviews, the case company saw vertical compatibility as strategy to unlock their end users. Of course, compatibility was perceived also as an important value driver in product design and future development. Moreover, easy integration and easy system setup was also perceived as a key factor to decrease the barriers to adoption. From the end user perspective system compatibility was seen as focal hardware feature. Hence, system interoperability decreases the barriers for trials and enhance fast deployment if the company's current software infrastructure supports the new hardware. Beside that the interviewees stressed the compatibility with current software tools and workflows, the immersive computing industry need new software applications in the future to entice new users to markets.

"The software will need to become intelligent enough to be able to benefit from these systems or you need new kinds of software." COO – Case company

Below in figure 11 is illustrated the strategical approach of the case company to unlock potential customers in B2B markets through current software developers. Further, as they are developing own software called Workspace, that will also entice new potential adopters to use their system and native software developers into their own platform. Moreover, the overall installed base of the HMD will increase the availability of new software applications and thus entice new software developers in the markets.

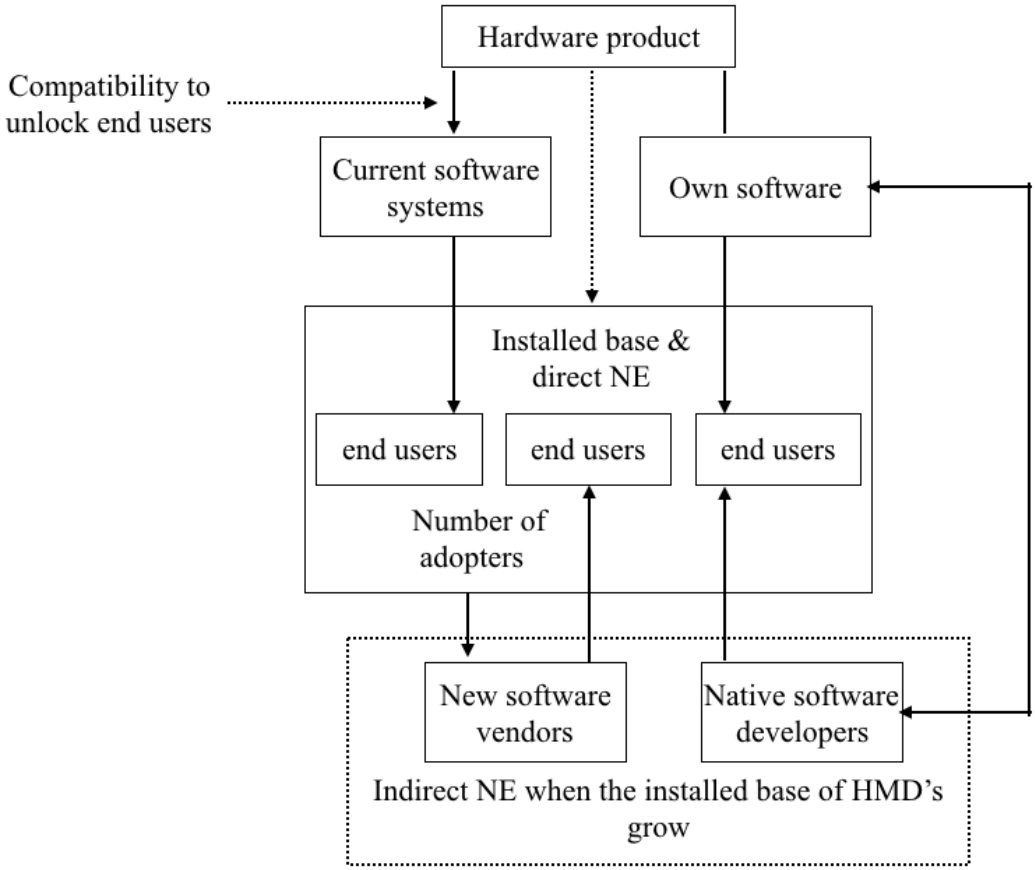

Figure 11. Strategic approach in B2B markets to unlock end customers through compatibility

4.1.4 Diffusion dynamics in B2B context

In previous chapters the results of the direct and indirect NE were presented. As the interviews suggest, direct NE value was not perceived crucial in the short-term among the respondents. However, the case company and end user companies are expecting more utility in the future as the multiuser capabilities improve. In contrast, indirect NE was seen as focal factor in the early phase of the product lifecycle to ensure system interoperability. Next, the results of the key concepts are summarized based on empirical data.

The diffusion and resulting product performance in the markets focused on the interlinked relationship between the case company, early adopters and compatible product/service partners. The context embeds the main factors to facilitate the early diffusion of the product. Hence, the emphasis of the product diffusion is on the related communication flows between all the actors in the 'pre-diffusion' context. In other words, the case company targeted the

product to identified organizations in key verticals. Further, like discussed earlier, the selected vertical partners and value-added resellers had significant role in the go-to-market strategy.

Pre-diffusion

The case company introduced their product in Slush event in 2017, even though their product was not even ready. The case company's target was early on to partner with the most innovative companies in the industry that could utilize their product in use cases never done before. The objective of this approach was to establish credibility within the markets by establishing collaborations with well-known companies in selected verticals that have prior experience with immersive technologies. From early on the case company had identified organizations inside their key verticals such as *design*, *training&simulation, research* and *engineering.* These selected companies were already advanced in using immersive technologies within their respective fields, and thus shown remarkable innovativeness toward immersive technologies within their domain. The product launch evoked interest within the target verticals and the case company gained a lot of inbound requests from the industry leading companies who wanted to test product. However, their product was still on the prototype phase and hence, they suggested that the first users would give them feedback on the product so that the case company could further improve its features. This approach enabled the case company to tweak some features that the early users proposed to do. Yet the case company had to ensure that the feedback was voluntary that there would be no IP issue risks. Moreover, the early product users got the opportunity the purchase the product among first ones, but they did not get any exclusivity deals.

The interviews with the case company employees suggest that they had defined their key verticals where their product would create value the most. In addition, like discussed earlier that the partner selection was based also on their ability to unlock potential markets. So, in contrast to the early user selection, the case company had also defined their key software and content partners. Hence, the communication strategy was very focused on these identified industry verticals. Like mentioned earlier, their go-to-market strategy was vertically and geographically focused land and expand approach. This ideology is based on the nature of B2B business that it is more effective, cheaper and faster to sell more to the existing accounts than to acquire a new one. Thus, instead of aggressively promoting solely

their hardware product, the case company published collaborations with the leading software vendors, content creators, first users, and value-added resellers.

In conclusion, the case company established collaborations with the industry leading software partners, first product users, content creators, and value-added resellers. The objective was to unlock potential end users and establish credibility within the target markets. For the diffusion perspective, the first user's role is especially important in B2B markets. Innovative companies can have significant role in disseminating information about the new innovation and its improved benefits. In addition, they are usually individuals inside companies that are product advocates and thus facilitate intraorganizational diffusion.

Innovators

From the case company perspective, the first users of the early prototype were important from many reasons. Like mentioned earlier, the case company gained a lot of valuable insights from every key vertical. The early users offered feedback how the product would serve them better in their specific verticals and based on those feedback the case company was able to improve their final product. Moreover, these identified users had previous experience of immersive technologies, they had needed technical capabilities in-house, and the know-how to utilize use cases that had been ever done before. Therefore, these companies were ideal for first users to use the most advanced technology in the world. Beside the technical capabilities, the first users were used for client endorsements to showcase the use cases.

However, public endorsements always include risks. Like the CMO of the case company explained, that finding the right person, the right brand, and combine them in the right use case is always difficult. Especially in the case of startups, the end user organizations are usually hesitant to publicly endorse new companies because most of the new high technology startups fail before reaching maturity. Therefore, there is always the risk of personal lost present in these endorsements. This became evident, and Company A representative mentioned that he had been against these kind of public endorsements in the past. But the case company's product and its quality ensured him, and he was ready to do co-marketing where they would reveal together the XR use case that had been done never before. This use case was pivotal in the Company A, and after publishing the use case to the world, both

companies gained a lot of media attention. In addition, the company representative said that because of the use case, they shifted their reputation from the traditional automotive company to interesting technology company. Further, the Company B representative actually said that specific use case ensured him about the case company's capabilities with the immersive technologies and he started to internally sell the idea of collaborating with the case company.

In conclusion, the role of innovators was perceived important as first users to offer feedback, establish credibility, and serve as spokesperson's inside their verticals. Consequently, one case company employee explained that the most important thing is to quantify the benefits inside each vertical. For instance, spokespersons in automotive industry cannot be used to assure the aviation industry about the product benefits. Hence, every vertical need their own quantified measures that can be then communicated through use cases or client testimonials. From the end user perspective, Company A perceived that their co-marketing project was really successful. The company gained a lot of publicity and was able to create more reputation as a technology company using frontier technologies. Company B has not yet worked as a spokesperson, but the company representative was looking forward about the future use cases.

Compatible software and service partners

The characteristics and key drivers for selecting compatible and software partners are discussed through these results. However, here are summarized the most critical ones. To distribute the most advanced immersive technology product in the markets, the case company selected value-added resellers to establish geographical distribution channels. Through discussions with the case company employees, it became evident that value-added resellers are key partners to serve their selected key verticals. According to interviews, selected resellers should add value in the sales process in terms of their know-how about the immersive technologies and ability to offer knowledgeable after sales support. But the most important factor in the partner selection was their ability to unlock enterprise markets for the case company. Hence, the more enterprise customers the software vendor or reseller has, the more interesting the partnership is for the case company. Therefore, value-added partners who can act as a channel for the physical goods and obtain right enterprise users as their clientele is a desirable combination.

However, the nature of B2B selling is usually twofold, as the case company employee explained earlier that they have to make two sales at the same time, one for the ultimate end-customer and one to ensure their software vendor. Thus, industrial purchase processes include many parties are, and especially with new the hardware/software systems that requires integration into organizations current toolchains and workflows. To overcome these perceived system uncertainties and risks about new innovation, compatible software and service partners has key role in expanding the potential markets and creating credibility.

Industrial brand to decrease perceived risks

The role of brand was perceived differently, depending on the interviewee and their role in organization. The perspectives of the case company employees concerning the role of industrial brand could be roughly divided into two factors. First, the brand was perceived as a source of quality, credibility and trustworthiness. By establishing partnerships with the leading software vendors, end user companies, and value-added resellers, the case company was able to create trustworthiness and credibility among their end users. One case company employee explained that B2B purchase decisions are rational, and thus based on hard facts such as product benefit, price, productivity or output increase. Therefore, brand value does not affect the initial product purchase decision in industrial markets. In contrast, one of the primary objectives in building quality perceptions and innovative associations is to collaborate with leading partners and software vendors in their verticals. Through these partnerships the company can have access to end customers that are interesting from the case company's perspective. Thus, partnering with well-known companies that possess clientele in desired verticals creates credibility within target markets.

From a different perspective, brand building in industrial markets was seen as efficient way to differentiate the product and communicate the value proposition with selected partners in co-marketing initiatives. Hence, collaboration with innovative companies where the companies are complementing each other was seen as ideal situation to create effective communication. Client endorsements were seen as very important communication strategy to communicate the benefits of the most advanced technology in the immersive domain and thus create credibility among the potential end users and partner companies. Moreover, by establishing personal relationships with end user organization personnel and finding the right

person for the endorsement is crucial. Hence, in addition with emphasizing the rational reasons in the industrial purchase decision, interviews suggested creating emotional connections with the brand. Instead of solely leaning on rational facts in the purchase decision, the personal relationships and trust between the companies were perceived important in creating emotional connections with the industry partners.

From the end user perspective, the supplier brand was seen as a source of credibility and trust. Both client companies underlined that they have encountered bad experiences in their careers regarding to suppliers' value propositions that they could not eventually fulfill. Hence, they said that one of the biggest barriers for adopting immersive technologies has been bad past experiences with previous companies. In contrast, both company A and B interviewees were impressed about the case company's technological know-how, capabilities in R&D and innovativeness. Further, both companies felt that they share similar values and company cultures as the case company. Moreover, they underlined that the mindset of the case company employees and innovativeness created early trust, and hence enabled further collaboration. For instance, both companies had specific use cases in mind where they needed the case company's help to fully deploy them. Further, Company A representative said that the case company embraced "can-do" attitude and offered all their resources to solve the problem and make it happen. In addition, the client organization A said that the successful use case affected their employer image and they were able to refresh their reputation as technically advanced in immersive technologies. For instance, now they receive job applications from the most experienced programmers and their trade shows are full of interested people to ask how they are utilizing immersive technologies in their organization. Thus, industrial brand can build employer brand and be effective in communication strategies to build reputation and perceptions about leading the adoption of new technologies.

Company B representative also addressed similar attributes in B2B brands. He noted that trust must be always earned, it cannot be bought. He also noted that their company is emphasizing the supplying company's proactive role in the collaboration. Hence, the personal relationships with the supplier are important to maintain the collaboration and together create novel value in the future. Moreover, the supplying company's ability to show constantly their innovativeness creates future proofing that was perceived important in the

Company B. Hence the supplying company is expected to be delivering value in the future, but with startups the continuity is always perceived as a real risk.

In conclusion, the role of industrial brand was perceived as ambiguous within the respondents. First, it was perceived as source of quality and credibility. Second, brand was seen as valuable asset that can be built through client endorsements within different verticals. These joint-use cases can be applied effectively for communicational purposes to build trust and credibility as an industry leading immersive technology supplier. In contrast, by establishing close personal relationships with key partners can empower emotional connections. From the end user perspective, supplying brand was also perceived as a source of quality, credibility and trust. However, the supplying company must first prove and quantify the value of their product.

Perceived barriers for adoption

As the interviewees have stressed, even though the new innovation is superior compared to existing ones, the initial adoption speed might be slow. Hence, the diffusion of new technologies was perceived as gradual and rather slow process. The tendency or bias to stick with existing technologies and reluctancy to change were constantly suggested themes in the interviews. As case company employees underlined, the technological advancement and technical capabilities varies within industry verticals. The conducted interviews revealed some barriers that are associated with the new immersive technologies. According to end user organization A, the quality and performance of the product and organizations perceptions that it is complex to use slow down the initial trials. Moreover, companies may lack of adequate in-house capabilities or dedicated people to use the innovation.

> *"I think that there is a threshold in peoples mind that it is very hard, but in my view, I mean this is just another desktop, it is a screen basically."*
> *– Senior Technical Lead, Company A*

Company B representative shared similar thoughts about the barriers for adoption. But in contrast, he saw that in their organization the biggest barrier has been the past negative experiences of previous immersive technologies. The supplying companies have promised

great performance and quality in certain areas but were not able to fulfill their value propositions. Also, the Company B said that their internal procurement department is causing real problems when they are purchasing new innovations. However, the most important factor in new innovation adoption decisions is the product benefit and how it will enable the organization to perform better in current areas and assert their key decision makers about the benefits. Moreover, the supplying company's ability to innovate, hence the future proofing of the organization was also critical factor to continue collaboration.

In conclusion, the perceived barriers to adoption varies between industry verticals. Hence, the case company has identified key verticals that they are opening with their key partners. Beside technical capabilities and innovativeness of the adopting company, the availability of software was constantly named as the biggest barrier for adoption. Hence, the cooperation between network partners such as compatible software vendors, value-added retailers and early adopters are important to reach the potential end customers. Communicating successful use-cases, deploying compatibility, and educating the target markets with the advanced benefits of the technology were perceived pivotal to overcome the barriers to adoption.

5 DISCUSSION

The results from this study presented above focused on exploring the characteristics of NE in industrial markets. The outcomes from the qualitative study was interpreted by using systematic combining approach. The focus was to answer the three research questions in this study. The first is more explanatory in nature and describes the main sources of direct and indirect NE value. The second explores connections and links how the case company could utilize NE to enhance the diffusion speed of their product. The third research question concerning industrial brand is connected to second question.

Hence, this chapter focuses on evaluating the empirical results and how they relate to current literature. Further, the meaning and relevance of the results are further argued. The ex-ante research framework applied in this study proved insufficient as new relevant concepts and themes emerged during the data interpretation. Hence, the *intrinsic product value*, *compatibility*, *reduced product* & *organization risks*, and *expected future benefit* are explained and evaluated. The idea is to give answers to research questions through these emerged themes. Below in figure 12 is the modified conceptual framework that comprises the concepts emerged trough interview questions.

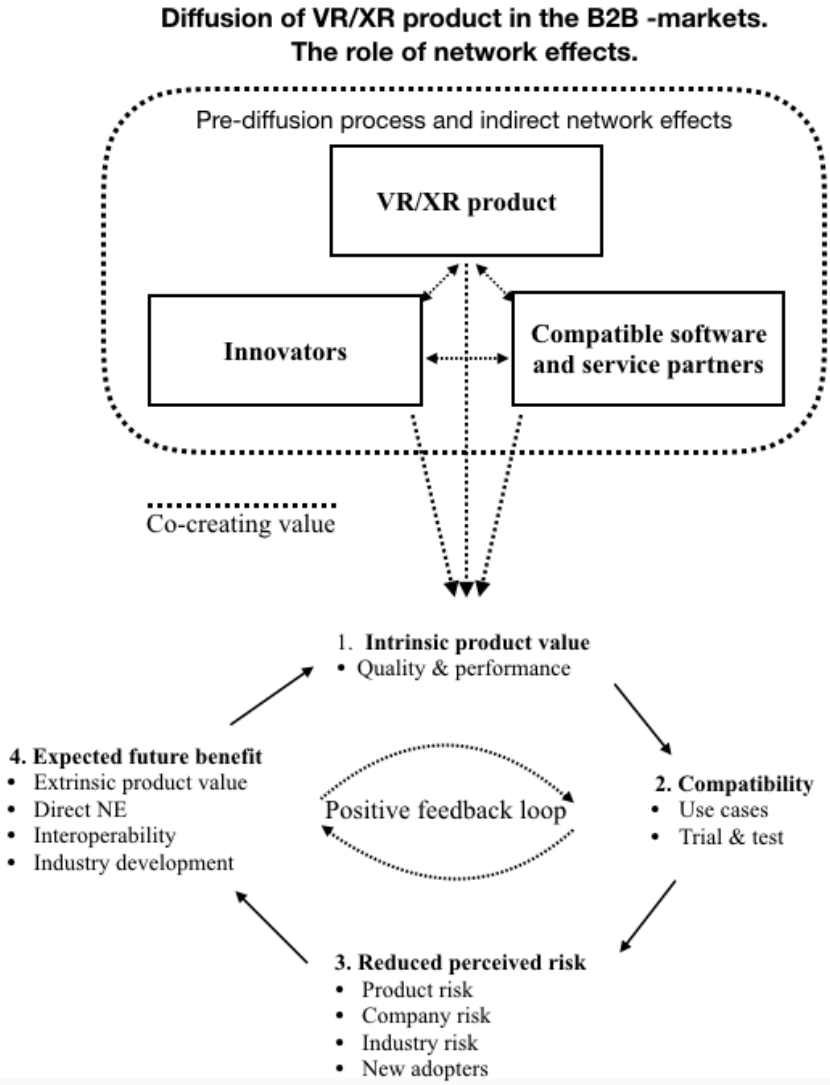

Figure 12. Modified conceptual framework

5.1 The nature of network effects in industrial markets

As the literature review indicates, the research about NE and its effects on industrial diffusion is insufficient. Contrary, the established researchers about the phenomenon in consumer markets is rather profound in many disciplines (e.g. Tellis et al., 2008; Srinivasan et al., 2004; Lee and O'Connor, 2003; Schilling, 2002). Thus, the existing literature does not offer any guidance to managers on how to successfully introduce a product that exhibits NE. The value of the phenomenon is derived from the userbase of the given product, thus the value of a product to its user increases as more people use the same good (Lee and O'Connor, 2003; Katz and Shapiro, 1994). Common examples of products that exhibit NE are found in

IT markets such as computer operating systems and compatible software (Farrell and Saloner, 1986). As the qualitative study indicates, the case company and their clients emphasized the product quality and performance as the de facto value source in the markets. The extrinsic value sources, direct and indirect NE, were found secondary in organizational purchase decisions. Reasons for this are manifold. First, the studied product is early on its lifecycle in a nascent industry where standard design rules and complementary markets are still emerging. Hence, the uncertainties related to technology and development of the industry may get the first users to seek primary value from the product quality and performance. Secondly, as the literature and conducted interviews suggested, industrial decision making is a long process where new innovations are evaluated carefully, and preliminary trials are deployed before initial adoption. Thus, fast market penetration is excessively difficult strategy for the supplying company in B2B markets to ensure large installed base early on. The interviewed client organizations talk more about the improved product benefits compared to predecessors and what kind of value the new innovation will create in their current workflows and toolchains. Therefore, their decision can be seen as rational comparison between costs and benefits where the initial decision must be justified for the top management. Hence, the new innovation must create some kind of advantage compared to current systems and its outcome should be measurable. Based on the results, these metrics can include innovations capability to improve organization's processes, increase productivity, decrease costs or work as creative tool. But the most valuable outcome of the case company's product is to enable the organizations to do things that they were not able to do before.

So, the case company and their end user clients are not emphasizing the direct NE of the product early in the diffusion phase. Therefore, the results of this study indicate that in B2B markets, the short-term objective of the supplying company is quite opposite to current views in NE theory (see e.g. Katz and Shapiro, 1992;1994; Farrell and Saloner, 1986) which underlines the importance to rapidly maximize the installed base of users. Beside that the value is evaluated from the product's novel benefit perspective, and the industrial buying decisions are multifaceted, the lack of focus on installed base might originate from the current product feature. At the moment, the case company's product cannot perform multiuser scenarios and therefore the "networked" value is rather obscure. However, the case company has started to develop a new feature that will enable the interconnectivity between

their devices, thus enable virtual collaborations where multiple users can work simultaneously. Moreover, the nature of installed base effects are rather different in B2B markets, especially with hardware devices. The potential consumption externalities are constrained to intraorganizational userbase. Hence, the units inside organizations that deploy VR/XR devices are still confined to collaborate together in immersive space. This intraorganizational collaboration can further spread to cover also interorganizational collaboration as the technology advances and become more wearable and everyday tool. Thus, technology advancement can potentially increase the direct NE among intraorganizational use and hence, create more everyday use cases for more employees within organizations. The current advancement of the technology can hence partly explain the results that future installed base didn't affect the purchase decision among the interviewed first users. Instead, the case company and their clientele underlined the intrinsic product value of new innovations and system compatibility.

Beside direct NE where the user's utility is an increasing function of the network's size (Farrell and Saloner, 1986; Katz and Shapiro, 1986), indirect NE has positive impact on user's utility trough product compatibility (Arthurs, 1994). The results of this study suggest that this positive relationship between product compatibility and product utility is present in B2B markets. Through the interviews, along with product quality and performance, product compatibility was constantly named as dominant factor in purchase decisions (clients) and product design approaches (the case company). As this study includes empirical data from the supplying company and end user perspective, the results are discussed separately. From *the case company perspective*, product compatibility was seen really crucial factor in product design and hence, primary strategy to acquire clients.

The case company employees stressed that their hardware product (primary good) is not a stand-alone, and therefore they need to establish partnerships with software companies to enable system integrations. Compatibility was seen as a strategical approach to "unlock" potential end user enterprises through qualified and leading software vendors. Thus, in contrary to current literature where the availability of compatible software applications is usually linked to the size of installed base (Arthur, 1994; Katz and Shapiro, 1994), the case company approach focused to open the markets by enabling their product compatibility with the leading software and content developers. Consequently, the case company was able to

entice the software developers to make their software compatible with their hardware before they had established sufficient installed base in the markets. Hence, this finding indicates that the case company made their product available for bigger markets and much more attractive for potential end users through compatibility.

From the *end user perspective*, compatibility was seen as important product feature and enabler in early trials. Hence, this finding supports current literature and suggest that also in B2B markets, the availability of complementary products may reduce the uncertainty of the initial product introduction with NE, decreasing the probability of start-up problem and consumer uncertainty toward the product (Ge, 2002). However, in this case, indirect NE does not occur due to the installed base of focal hardware but instead of collaboration between the case company and software developers. Moreover, the end user organization responses are in line with the current notion that although customers may experience problems evaluating the product itself, the presence of other compatible products may help their decision, as the final value of the combination will be higher than the value of the isolated product (Shocker et al., 2004). During the interviews with end user organizations, it became evident that the case company's compatibility with their current systems was also a major factor in their initial adoption decisions. Easy system integration with company's current workflows and toolchains was perceived evident as well as the availability of useful software applications. The factors behind organizations need for compatibility were major investments in current IT-systems and workflows, and the availability of useful software applications. Thus, organizations have built their current software infrastructure during the years which can make the compatibility sometimes problematic issue.

Moreover, the perceived switching cost are significant, if the organizations would need to make major updates or even abandon current systems to implement new hardware tools in their workflows. But for instance, the client organization B representative noted that if the new innovation will give them massive benefits then they would update their current software and hardware systems to implement the new technology. It must be noted that the company is multinational conglomerate and thus hold major resources and in-house capabilities to make significant new investments. Hence, the finding supports current literature that early adopters and firm characteristic such as size are typical factors that affect the adoption of new innovations (Rogers, 2003). In addition, the results suggest that bias

toward current legacy systems is relevant in B2B markets. According to empirical evidence, the perceived switching costs, technology uncertainty, vendor switching costs, and system compatibility issues slow down the diffusion speed in different industry verticals. Thus, industrial markets tend to also exhibit excess inertia and organizations are *tipped* toward legacy systems. Like discussed earlier, the advancement in technologies and technical capabilities of organizations varies between verticals. Therefore, many organizations are delaying their decision to adopt that the technology and industry matures, the product become easy to use, comfortable to wear for a long period and the availability of new software applications are available. Especially the critical amount of software and complementary products were seen as critical drivers of future demand for the product and thus the result hold true with previous literature findings (Tellis, Franses and Binken, 2007).

In conclusion, the empirical results indicate that in short-term, buying organizations in B2B markets are primarily seeking intrinsic product value (attributes/features) and it appears to more dominating factor than direct or indirect NE of the product. Therefore, in contrast to current approach in NE literature, pursuing compatibility B2B organizations can unlock potential end customers and therefore they don't have to wait software applications to evolve. For instance, the findings support the same outcome as Vowles et al. (2011) study, that the future size of networks is not significant in B2B innovation adoption decisions. This might be explained by the same factors that the first users are not interested about the future size of the network because they have already committed to the supplying company (Vowles et al., 2011). But in contrast, the organizations are expecting the new innovation to spread inside their organization in the future, and hence increase the installed base inside their own organization. The interviews suggest that end users are expecting the new innovation to be adopted by more than just 2-3 users inside the company to utilize more benefits, for example in collaborative purposes. Hence, organizations are not necessarily expecting or even wanting that other organizations will start to implement new technologies that might create competitive advantage.

Hence, the findings indicate a linkage between product compatibility and future installed base of the case company's product. As the product features will evolve to a direction where virtual collaborations are possible, thus enabling multiuser capability to interact in the immersive environment simultaneously, might have huge impact on the future performance

of the product. Beside the collaborative perspective, many previous studies suggest that the more application software is available for an operating system, the more value the end users will gain when using the hardware system (Lee and O'Connor, 2003). Thus, the findings indicate that the number of compatible software and complementary goods are positively affecting the diffusion speed of new innovation in B2B markets.

5.2 How to utilize NE in high technology product diffusion in B2B markets

As presented in the results, product quality and software compatibility of the hardware product are predominant factors in industrial decision making. Whereas the indirect NE had positive link on the early product diffusion in B2B markets, direct NE derived from the installed base of the product did not seem significant among the respondents. However, the relevance of future installed base is significant factor in long-term, especially if the product has the possibility to exhibit direct NE. This became evident during the interviews and both client organizations as well as the case company acknowledged the novel value in the future as the VR/XR HMD's enable multiuser scenarios. For instance, these virtual collaborations will further drive the importance of the product's direct NE and create consumption externalities within organizations.

As suggested in the modified conceptual framework above, the NE and diffusion of new innovation is multifaceted process and affected by many factors. Based on the interviews and data analyzes with Nvivo, the emerging themes suggests that organizations in B2B markets are focally searching for novel value in new innovations. Thus, the *quality* and *performance* of the new innovation must outperform its predecessors. Therefore, industrial decisions are driven predominantly by the technology's ability to create value in their processes. Secondly, *compatibility* was perceived as important, especially with new hardware products that need to be integrated into current workflows. Third, the findings align with current literature that new innovations cause *uncertainty* and *risk* perceptions inside organizations (Kim and Srivastava, 1998). To overcome these product and vendor related risks, proved product quality and credibility trough actions were named as important ways to build trust. Lastly, the *future expectations* are guided by the supplying company's ability to keep innovative, invest in R&D, create more novel value as the user base increases and entice more complementary companies to enter the markets as the overall industry

matures and advances. Thus, markets are expecting signs of future proofing and improved quality in software applications as the installed base of the focal product increases.

According to this study, previously mentioned factors are relevant to facilitate early trials and utilize NE in industrial markets. Thus, companies that are aiming to introduce products that exhibit NE in industrial markets should focus on *the intrinsic product value*, deploy *compatibility*, reducing *perceived product and organization risks*, and managing the *expected future benefits*. Next the concepts and their implications are briefly introduced to explain how they can be utilized to enhance the diffusion of industrial high-technology products.

The relationship between product quality and initial reason for product purchase was dominant trough the data analyses and interviews. This finding is supported by many current theories (e.g. Frambach, 1993) since it can be a distinctive competence, contribute significantly to the success of a firm and hence be a source of competitive advantage in the marketplace.

To facilitate diffusion and early product trials, product *compatibility* emerged from the data as significant attribute in product design. As said earlier, from the case company's perspective compatibility is crucial in product design to unlock potential end customers and expand their reach in identified verticals. Conversely, end user organizations perceived compatibility as a factor that enhance their positive associations toward new product, as the system setup would become much cheaper and easier. In addition, this will further offer more available software applications for the end users, depending how many collaborations the supplying company has managed to establish.

In addition, current theories suggest that industrial organizations are carefully evaluating their product decision, hence proper risk management measures are taken before initial adoption (Kim and Srivastava, 1998). During the data analyzes, the supplying company underlined the importance of reducing the perceived risks and creating trustworthy reputation. Consequently, *product risk* is prevalent in a nascent industry where the uncertainties of the supply of software, proper after sales services and non-standardized industry environment exists. Hence in B2B markets, companies utilize product trials to

evaluate the product quality and performance before initial adoption. The empirical findings support the perspective that uncertainty in quality, system incompatibility with current systems, and vendor-related switching costs are delaying the decision to adopt and implement new innovations (Kim and Srivastava, 1998). As one case company employee explained that companies does not buy innovation, they buy safety. This argument is supported by their end user companies, who both shared previous bad experiences about supplying companies that could not fulfill their value propositions. Moreover, current literature has also studied this phenomenon, and Herbst and Merz (2011) found that B2B brands also fulfill a risk reduction function by establishing trust between the supplier and buyer. Hence, even though the product benefit is obvious, the supplying company must arise credibility and trustworthiness within potential buying organizations. Previous research has found similar evidence and Schmitz (1995) suggest that a strong industrial brand can help minimize the perceived risk related to the selection of a wrong business partner.

Lastly, the value of any company is dependent on its ability to create value in the future, hence customers are making expectations of its future capability to deliver that. The development of computing industry and increasingly connected world is driving the future expectations of the technology. It became evident, that both the case company and their end users are more value generated in the immersive computing in the future. When asked about the possibility of multiuser and virtual collaboratives scenarios in the future, the answers were unanimous that it will be a big driver of value. This finding supports the current presumption that NE affect the future expectations of the product benefits (Hall and Khan, 2003). In addition, Rosenberg (1972) explained that supplying company should make improvements to the technology after its introduction, invent new uses for the technology and the overall development of complementary inputs are effective ways to manage the future expectations of potential adopters. Thus, the case company employees and end user organizations are driving the development for multiuser immersive experiences. The need for multiuser virtual collaborations derives from the fact that work is usually done in teams, hence collaboration is essential nature of projects.

In conclusion, the modified conceptual framework combines the factors that are crucial before the supplying company's product can exhibit direct and indirect NE. Contrary to current literature (Katz and Shapiro, 1994), the findings of this study does not suggest that

early adopters are biased toward legacy systems, thus there is no excess inertia. These findings are relevant to current studies that suggest that even inferior products can "lock-in" markets and hence establish dominant position in the markets. In contrast, B2B markets are carefully evaluating new innovations, thus minimizing the risk of choosing the wrong supplier and looking for safety in terms of technical issues. Therefore, these results suggest and are supported by studies (e.g. Vowles et al., 2011) that collaboration with network partners and early product users is effective approach to facilitate the diffusion of innovation in the target markets.

5.3 The role of industrial brand in diffusion process

As suggested in the results, industrial brand can create trust, credibility and hence decrease the perceived risks in purchase and trial decisions. These finding are supported by the current studies that also encompass brand's role to evoke positive associations, create trust and reputation (Mudambi, 2002). Hence, industrial brand is an important intangible attribute in business purchase decisions. However, the benefit of branding seems to be ambiguous in industrial domain.

The research results indicate that branding is a prominent way to establish reputation, develop trustworthiness, create credibility and establish distinctive value propositions to differentiate supplying company's products in highly competitive industrial markets. The results of the analysis indicate that especially new startups operating in a high technology discipline should establish quality image. This can be achieved by offering high quality product, collaborating with well-known partner companies with high technical capabilities to create credible brand. Thus, findings suggest that trust is a key attribute in B2B markets where the current organizational buying criteria is based on rational aspects. Conversely, interviews suggest that brand should also evoke emotion in target markets to complement the rational reasoning and functional benefits of the perceived product. Research findings are supported by previous studies that brands have the emotional benefit of reducing perceived risk and uncertainty for the organizational buyer, thus increasing their purchase confidence (Mudambi, 2002). Especially, brands role to increase the purchase confidence became apparent in the results. This finding is relevant as both buying organizations stated that biggest barrier for adopting new immersive technologies have been so far the bad quality of the devices. They had collaborated with companies who created high expectations of their

products but could not deliver what promised. Hence, these past negative experiences created trust issue toward the whole industry.

Thus, new companies introducing high technology products in B2B markets can build trust trough by collaborating well-known partner companies, establishing personal relationships with different stakeholders, developing in-house capabilities and value-added reseller network. Hence, findings indicate that B2B branding is important in markets, where the product offering involves high perceived risks in e.g. relating to switching costs, technological risks, vendor related stability, and availability of complementary goods. Therefore, branding implications can positively affect the B2B decision making and facilitate more deeper collaborations with key partners in the industry network.

In addition, client organizations can also benefit from and partake in developing the supplying company's brand. According to the results, client organization A stated that their company benefited from the co-marketing activities with the case company. These co-marketing activities enabled the company to create more advanced brand image within high technology domain thus shifting their brand perception from traditional automotive producer toward high technology company. Hence, co-marketing strategies can be very beneficial for the supplying company and their clients to enhance brand image within target markets. Thus, results indicate that B2B co-operations can unlock potential markets through quality partnerships and create valuable associations that are beneficial for both parties.

In conclusion, the results indicate that the B2B brand is valuable asset in industrial decision-making evoking trust and credibility. These attributes reduce perceived product and organizational risks, thus further strengthening the emotional connections with the supplying company. Current literature supports these findings stating that trust and commitment are key attributes in buyer-seller relationship (Morgan and Hunt, 1994), hence making the issue to evoke them in business relationships very important (Mudambi, 2002).

6 CONCLUSIONS

The concept of NE and its implications in B2B markets is topical due to the increased digitalization and advancements in different technologies. The phenomenon is well studied in many product categories and disciplines, but thorough studies in B2B markets are still insufficient. Hence, organizations introducing new innovations in B2B markets exhibiting NE could make a better decision if the effects of the phenomenon would be better studied. Thus, in the following sections, the findings of this study are summarized, and the potential contribution is discussed. The empirical findings and their managerial implications are inferred from analyzed data and reflected in current theories. Lastly, the limitations of this study are examined to offer opportunities for further studies in the field.

6.1 Theoretical Contribution

The standpoint of this thesis was to study NE in an industrial context. The rapid technological advancement and digitalization of industrial tools are interlinking people and organizations across fields, hence transforming many traditional markets into markets with NE (Podoynitsyna et al., 2013; Goldenberg et al., 2010). This study focused on investigating the nature of high technology product diffusion in B2B markets. Mainly, how direct and indirect value can be created in B2B markets to facilitate the product diffusion process. It became apparent that technological advancement and organizational capabilities vary among different industry verticals; hence it is essential to identify 'innovator' type of organizations and individuals to target the innovation. Similar to current NE studies conducted in different fields (see e.g., Lee and O'Connor, 2003; Katz and Shapiro, 1994), the availability of software applications and content for focal hardware are crucial determinants to introduce new hardware systems in industrial markets successfully. Next, the findings of each research question are summarized.

The first research question addressed the nature of NE in the industrial context and how the different concepts fit in the B2B market dynamics. Based on the findings, it became apparent that the *intrinsic* product value (attributes/features), the quality and performance of the innovation was the predominant determinant in target populations decision-making. Thus, contrary to current theories (Katz and Shapiro, 1994; Farrell and Saloner, 1986), the early users are not concerned about the external utility derived from the installed base of the

product. However, there must be a sufficient supply of available software applications to implement new hardware technology. Thus, "innovator" organizations are innovation-focused, and decisions are driven by the functional benefits of the given product. However, in the long-term, early users are also expecting increased utility in software availability and intraorganizational implementation of the product as the userbase increases.

Second, research findings indicate that *indirect NE,* such as product compatibility and adequate supply of available software applications, are crucial factors to unlock potential customers and ensure early trials. Many scholars agree that the availability of software and positive feedback effects makes the focal product more attractive (Lee and O´Connor 2003; Farrell and Saloner, 1986). Hence, the case company's market entry strategy was based on establishing partnerships with leading software vendors to ensure their system compatibility and to unlock target enterprise customers. Establishing quality partnerships was seen strategically crucial in a nascent industry, where standards have not yet emerged, and system interoperability is a critical factor to establish credibility and facilitate early trials. Therefore, early collaboration in the pre-diffusion phase with industry network partners is essential to unlock potential end customers, collect feedback from early users, and use opinion leaders to disseminate information about the benefits of new technology.

The second research question complemented the first by suggesting how companies can utilize NE in B2B markets to facilitate diffusion. The findings suggest that in B2B markets, the *direct NE* value derived from the installed base users do not significantly affect the purchase decision among early users. Hence, to facilitate diffusion and create early demand, organizations should collaborate with leading software vendors to unlock end customers and create a high-quality reputation among their target verticals. These partnerships can further reduce the perceived risks and uncertainties associated with new technology. As discussed earlier, organizational buyers face many critical evaluations regarding vendor-related switching costs, software updates, and system compatibilities (Kim and Srivastava, 1998). However, in contrast, results indicate that these risks are sufficiently decreased as the technology and industry mature. Further, organizations are expecting the innovation to be deployed in organizations more widely in the future. Hence, the technology should have a "networked" feature to create utility gains as the userbase increases. One potential and identified factor is a multiuser capability that could enable collaborative design reviews or

virtual meetings within the organization. These virtual collaborations can have a significant impact on the case company's product expected future benefit and hence exhibit direct NE.

Below in the figure 13 is illustrated the case company's approach to unlock potential end-users in B2B markets. The purpose of this strategical approach is to collaborate with leading software vendors who have existing customers among target industry verticals. This can be achieved by system compatibility to enable easy integrations to organizations' current workflows. Moreover, as the installed base increases as a result of this approach, this will further entice new software developers to enter the markets. In addition, the case company is developing its Workspace software application that can incentivize native developers for the platform. The direct NE is derived from the future multiuser scenarios where the users can collaborate in a virtual environment by exchanging data and feedback. Further, the development of the industry and emerging standards will enhance the interoperability between different systems facilitating the positive feedback effects in the industry.

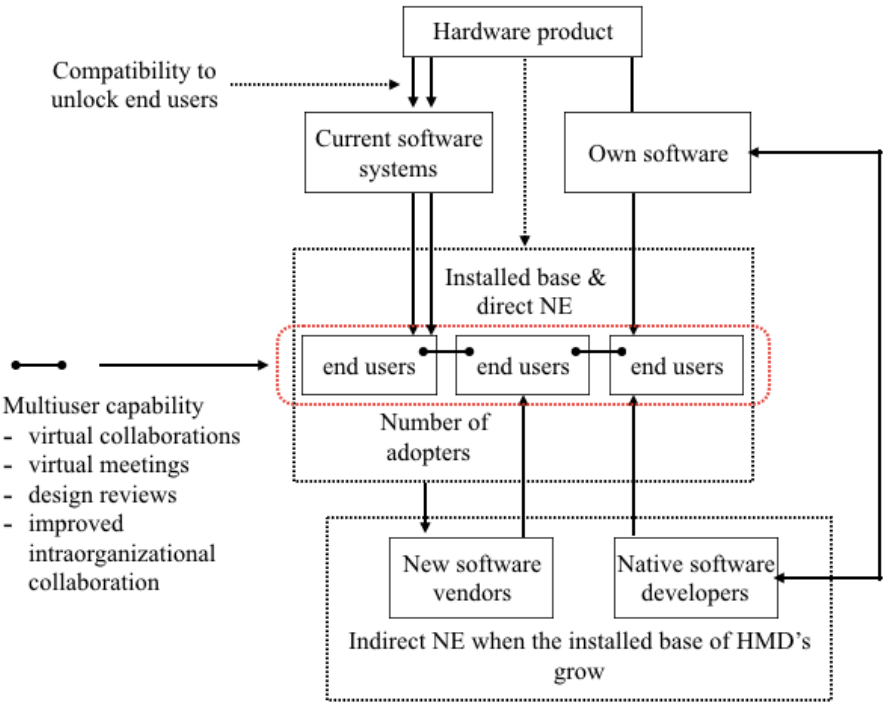

Figure 13. Strategic approach to create direct and indirect NE in industrial markets

The third research question studied the role of the B2B brand and its role in industrial markets. The results indicate that the B2B brand can be perceived as a source of credibility and trust to reduce the perceived risks. These results contribute to current literature and propose that B2B collaborations can enhance the perceptions of quality and create positive associations among the target markets. Moreover, establishing emotional connections and personal relationships with stakeholders can further improve the continuity and openness of the collaboration. This finding is supported by (Mudambi, 2002) who underlined the need to understand further how customers perceive the company brand. Hence, B2B managers should implement decisions and actions that aim to build credibility, continuity, and improved product performance.

Thus, collaboration with industry partners such as first user organizations and complementary goods suppliers are essential channels to establish credibility and unlock potential end customers. Thus, research findings support recent studies (Vowles et al., 2011) that networking with producers and users of innovation are essential strategies to establish early credibility in the markets. Further, findings contribute to the current knowledge that technology suppliers should seek a co-operative role and search opportunities to become part of the customer's more comprehensive business model comprising the actions, needs, and structures (Makkonen and Johnston, 2014). Findings of this study support this perspective, and during the interviews, case company employees and their clients underlined the fact that traditional supplier-buyer transactions are insufficient. Hence, they underlined the importance of deeper relationships, such as sharing the same values and company culture to strengthen the collaboration. These further enhance the development of social (credibility, trustworthiness, commitment) and technical (e.g., compatibility, system integration, joint relationship strategy) ties between companies (Makkonen and Johnston, 2014). Also, joint activities as co-marketing were found very beneficial from the case company and buyer's perspective.

In conclusion, these findings support that organizations do not purchase innovation; they buy safety in terms of continuity, product performance, quality, and trust between the participant companies. In a nascent industry, a strong B2B brand can decrease the perceived risks and ultimately create an emotional commitment to the supplier. Various scholars have found similar evidence (Lynch and de Chernatony, 2007; Webster and Keller, 2004) that

perceived risk is typically associated with the more complicated and higher cost purchases that are usually inherent within high technology industrial markets. Therefore, organizations in B2B markets should also focus on building a robust industrial brand to minimize the perceived risk related to the selection of a wrong business partner (Schmitz,1995). Thus, besides rational and functional benefits, emotional connections are essential to strengthen the relationships. The results contribute to the current knowledge that B2B brands reduce the perceived risk of investing (Homburg et al., 2010) and create trust and reputation from a customer perspective (Cretu and Brodie, 2007) in enterprise high technology product category.

6.2 Managerial Implications

There are several implications that the case company can implement in order to utilize NE in their product diffusion. However, the relationship between NE, the development of immersive technologies, and the organization buying process is creating a dynamic market environment. Hence the NE phenomenon is an ambiguous paradigm, but data analysis and extant literature offer a guideline to enhance the product performance in target markets. The practical recommendations of this study are based on solutions to maximize the *extrinsic* value sources of the product in the future while maintaining the high quality of the functional product.

To enhance the extrinsic product value sources and create NE in the industrial market context, following objectives and industry environment themes emerged. Also, to distinguish the areas that affect the NE, diffusion is categorized into **product**, **end-user,** and **industry-related** factors.

The case company should focus on developing ***product-related*** factors that enable multiuser and collaborative scenarios in the future. The research results indicate that current end users are underlining the importance of virtual collaboration capability in the future. This feature would increase the user's utility as they would be able to interconnect with other similar HMD's in a synthetic environment. This virtual collaboration would further drive the intraorganizational diffusion by enabling (1) collaboration between units, (2) internal reviews, (3) virtual collaboration, and (4) virtual meetings. Thus, this would create a significant value shift from working individually compared to working in a virtual

collaborative space. First, organizations would be incentivized to buy more units as the HMD's can interoperate and create more value in collaborative spaces. Secondly, collaborative product capability would enhance the intraorganizational diffusion and selling process. The benefits of the product could be demonstrated through personal experience in virtual collaborative space straight to the decision-makers.

Further, increasing collaboration between industry partners is driving the value creation in interorganizational activities. Hence, the increasing interdependency with stakeholders and increased collaboration across industry boundaries are driving the possibility to utilize the multiuser collaboration of the HMD in (1) joint-projects and (2) value chain management. This interconnectivity would create direct NE between the key industry partners and creating more opportunities to utilize virtual collaborations in an immersive environment.

Below in figure 14 is presented the current state of the technology and future improved implications as the virtual collaborations will be enabled between multiple users. Also, the two-way communication will further create direct NE, as the utility of HMD users increases as new users join the same immersive experience. The multiuser capability enables the constant feedback and input of other persons in the same synthetic world.

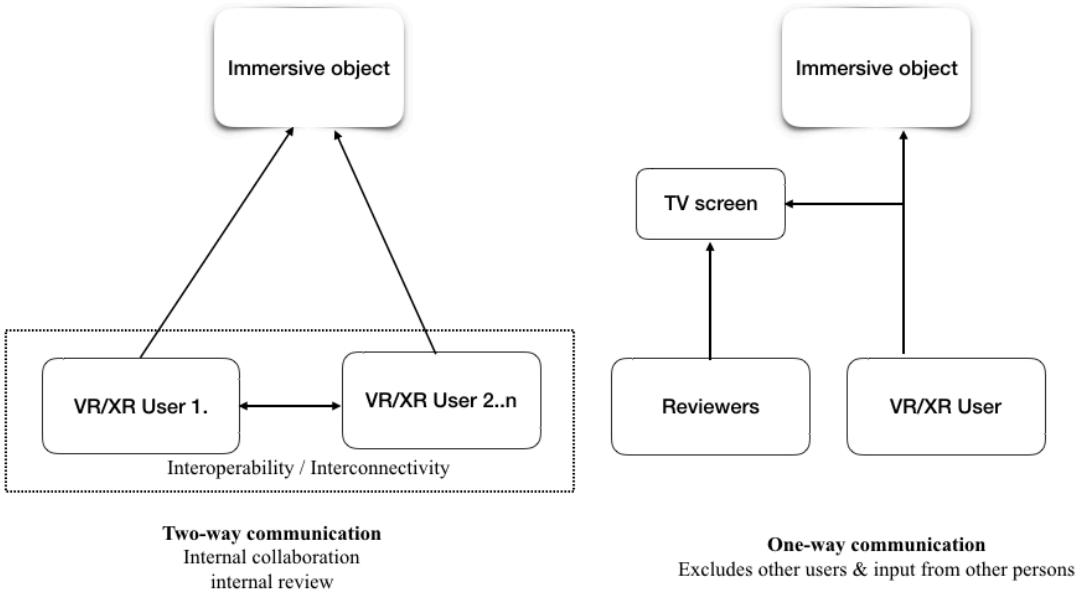

Figure 14. Demonstrating collaborative multiuser-scenario between two or more interconnected HMD devices.

End user-related factors emerged during the literature and empirical data analysis. To ensure the product compatibility with existing toolchains and workflows are critical. With hardware/software systems, ultimately, the availability of content and useful software applications will determine the success of the innovation. There, enticing new software developers to markets, making the hardware compatible with current software systems, and developing own software applications will create positive future expectations of the technology. Hence, the availability of software is critical for user trials and product evaluations. As the technology and industry advances, different complementary hardware/software tools for analyzing, modeling, and processing the data will become more important in the 3D environment. Therefore, the role of complementary and supplementing tools are needed to increase the attractiveness of the industry for later adopters and further facilitate the spread of the product.

Finally, ***industry-related*** factors include the overall development of technologies, industry infrastructures, competition, regulations, and data security issues of the immersive technologies. In a nascent immersive computing industry, all the hardware and software vendors are still working in a rather nonstandardized environment. Thus, when the standards start to emerge, the case company should take an active role to determine to the direction of the standard designs. In the best case, standards can favor the case company. For instance, current software developers and CAD tool vendors are currently dominating the 2D environments. Thus, system integrations enabled by plugins or software updates would potentially unlock new market segments for the case company. Thus, current 2D toolchain developers have significant negotiation power in terms of whether they want to make their systems compatible with the case company's VR/XR HMD device. They might fear that their current customers will strand them and switch to a new, improved system, hence making their tools obsolete. Nevertheless, there is always a considerable switching cost included in B2B markets when organizations change or make upgrades in their current software systems.

Consequently, these shifts from current toolchains to new ones take time. To overcome to gradual nature of industrial diffusion, the case company could entice product trials with onsite demonstrations, product leasing, or offering free limited-time site-licenses to demonstrate the relative advantage of their product over the competing alternatives. These could decrease the perceived technological uncertainty, complexity to use, and switching cost. Further, organizations could still deploy their legacy systems while evaluating the product, thus minimizing risks in continuity in production. Moreover, the sales personnel could offer consultative services for organizations that are interested in the benefits of immersive technologies. Personal experiences of the technology would create a more trustworthy image of the company and product. Also, these services could also include closer collaboration, for example, solving customer problems with immersive technologies.

In conclusion, factors such as the wearability and ergonomics of the product in dedicated task environments are important form the user's perspective. Hence, these will further improve the user experience and drive the workflows into 3D virtual environments in the future. Further, the case company's workspace application will drive the value shift from the physical world to more immersive and synthetic environments. Besides, this shift is endorsed by the unique value of direct and indirect NE. Consequently, the case company's ability to create direct NE will enhance the *intra-* and *interorganizational* cooperation in various use cases. These will drive the transformation of the product to become an everyday tool in organizations instead of just used for specialized use cases.

6.3 Limitations and Future Research

This research comprised theories from various disciplines such as NE, B2B diffusion literature, and industrial brand. Hence a priori theoretical framework needed modification, and a new conceptual framework was conducted during the analysis as relevant themes emerged from the data. The timing of this study presented opportunities to study the NE phenomenon in a nascent industry where system standards have not emerged, and the product is early on its lifecycle. Hence multidisciplinary perspective and systematic combining approach enabled a continuous movement between the empirical world and the model world. Thus, research issues and the research framework were successively reoriented when confronted with the empirical world.

Regarding the generalizability of the findings, one obvious limitation of this study was the small sample size to make the results more robust. Conducted interviews included a total six informants, four inside case company employees, and two end user organizations. In order to understand the organization's perspective more thoroughly about the intrinsic and extrinsic product values, future research should focus on increasing the sample size. However, both end user organizations shared quite similar opinions about the NE phenomenon, product values, and the role of the future installed base. Nevertheless, it cannot be said that the data reached maturity; this outcome might be coincidence or way of interpreting the phenomena in innovative organizations.

Hopefully, these research findings can complement current literature and generate ideas for future studies. In the future, it would be interesting to study the extrinsic product value more thoroughly in industrial markets. Moreover, the overall development of the immersive industry will offer exciting opportunities for future research, for instance, how intra- and/or interorganizational collaboration change as the possibilities of VR/XR technologies become more widespread and the technology has matured enough.

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APPENDICES

Appendix 1. The key words used in the key word search for the study

Network effects	Network effects, Network effects in industrial markets, network externalities in B2B markets, direct and indirect network effects.
Industrial diffusion	Industrial diffusion, diffusion in industrial markets, B2B diffusion, industrial adoption.
Industrial brand	Industrial brand, B2B brand, industrial branding.

Appendix 2. The interview questions for case company employees and their clients

All the interviews were semi-structured in nature and the interviewer recorded all the interviews for this research purpose only. Below you can find the interview questions for the case company employees and their clientele. Before each interview, permission for recording was granted.

Interview topics/questions: Case company employees

1. Name, title, and work experience in years.
2. Shortly, can you describe your main job responsibilities and the industry you work in?
3. How do you perceive the current state and the future of immersive technologies across industries and organizations?
4. What are the biggest obstacles to mass adoption of immersive technologies in industrial markets?
5. What kind of benefits an enterprise or user can achieve with your product?
6. How much previous knowledge/expertise of immersive technologies a person/company needs if they want to buy and implement your product/system?
7. What factors are most important for you when making decisions about new partners?
8. When speaking of added value from your perspective in partner selection, what attributes are you emphasizing in order to benefit from partnership?
9. How you create value for potential clients and lower their barrier to adoption in fairly new markets and product category?
10. Can you describe your go-to-market strategy and what you chose to partner up with these particular companies?
11. How do you perceive the role of "opinion leaders (client endorsements)" in your marketing communications?
12. How important is your product compatibility with other available software & hardware systems in the markets?
13. How valuable/critical is the interconnectivity of immersive technology products in the future?
14. Do you see any other value drivers of your product besides the functionality/performance as the user base increases in the future?

15. In your opinion, what it takes for your product to become the system standard in industrial markets / in your target markets?
16. What kind of brand attributes do you value in partner companies, why?
17. In business-to-business markets, how do you perceive the role of the brand?
18. In your opinion, what are the benefits of branding in B2B markets?

Interview topics/questions: Client organizations (end users)

1. Introduction: Name, title, and experience in the field.
2. Shortly, can you describe your main job responsibilities and the industry you work in?
3. How do you perceive the current state of immersive technologies in your industry and organization?
4. What are the biggest barriers to adopting immersive technologies in enterprises?
5. Could you describe your decision-making process when selecting new products before initial adoption and implementation?
6. What factors are most important for you when making decisions about adopting and implementing a new high-tech product in your organization? (product or organization related?)
7. As an early adopter of the Varjo's technology, what were the critical attributes for trial and implementing their new technology?
8. How would you describe your cooperation with Varjo?
9. What kind of benefits do you value in immersive technologies (VR/XR)?
10. How much know-how or technical capabilities does it require to implement immersive technologies in enterprises?
11. How important is the system or product compatibility with the company's existing software & hardware infrastructure?
12. How critical is the interconnectivity of two or more immersive technology products? For example, multi-user capability.
13. Do you see any other value attributes besides the functionality/performance of certain product?
14. Can you see added value in the future as the installed base of VR devices increase across industries and organizations?
15. When comparing different supplying companies, what kind of value do you put on the supplying brand?
16. What kind of brand attributes do you value in supplying company, why?
17. In business-to-business markets, how do you perceive the role of the brand?
18. What are the benefits of branding in B2B markets?

Appendix 3. Exemplary interview responses

In this study, the following main concepts and their exemplary interpretations by interviewees are put together in tables below. There are two different value sources in network effect markets, direct (installed base of users) and indirect (compatibility and complementary goods).

Table 1. Exemplary interview responses considering the main concepts of NE

Quotations from interviews conducted for this study	
Interviewee	RQ: How important is your product compatibility with other available software & hardware systems in the market?
CMO - case company	• *"Really important, without that one, without software compatibility our product doesn't function, so it is a basic guiding block in a way to create software compatibility and because we are not a stand-alone product."*
COO – case company	• *"We also invest into working with software vendors, not because we would think they will sell a lot of our hardware but obviously the more software that supports our system or is compatible with our system, the more ultimate end-customers i.e. the enterprises will find it easy to adopt and take the step up to immersive computing."* • *"Hardware is not a problem, and software is a journey where you are not ready because there are like hundreds of thousand commercial software in the world and of course, you need to start from the ones that unlock most of the market. But if we are not compatible, nobody can use our system for anything, it's always used together with some third-party software."*
Partnership manager – case company	• *"The openness of our system is kind of a compromise; we want the companies to get the maximum performance out of our headset but at the same time we want to have the maximum number of software developers. So, you make a compromise in quality if you use the open VR standard but then you limit the number of software partners and the total access of the market with the native integrations so there is a compromise."*
Sales manager – case company	• *"That is very crucial, so without the compatibility there would be no value in the headset itself. There are some software's that we could do the integration ourselves, but it still requires the integration, so you always need end-user software to use our headset. Software is like 50 percent of the whole system and another 50 percent is hardware."*
Clientele	RQ: How important is the system or product compatibility with company's existing software & hardware infrastructure?
Senior technical leader – Client A	• *"{…} that is super vital, it is super important because we are handling enormous amount of data every day and everything is updated every night. Each morning when you come to work, it is another car out there, I mean the car has changed in a many different ways. So, if you want to have a process where you have the latest car and VR every day, you need to have a super good pipeline for that."* • *"It is really important that you have a workflow that is prepared to handle high-end rendering internally in the company otherwise, it is a huge struggle, I would say to bring in a new type of hardware and software's."*
Group Scientist – Client B	• *"It is important, not always critical. It depends what benefit it is giving us. If it's giving us a massive benefit, then we will look up in our workflows, change our computers and upgrade them."*

- *"From a software perspective, if for an example, we couldn't use Unity or Unreal, then that may have been a real problem. (...) We invest a lot of time for new software's and it's a huge task. (...) Hardware can be bought, software takes a lot more time."*

Table 2. Exemplary interview responses of multiuser scenarios.

Interviewee	*RQ: How valuable/critical is the interconnectivity of immersive technology products in the future?*
CMO – Case company	• "It is a really important. We learnt that these multi-user scenarios are important."
COO – Case company	• "Almost everything that happens in that space (B2B) is collaboration, there is not much work that is been done completely alone. And hence, being able to create these kinds of multiuser scenarios is very essential and what we do."
Sales Manager – Case company	• "That is very crucial, just like with computers nowadays they will be interconnected in a way that you can just dial into a design review meeting as you would with any other device, like a Skype call." • "This is very crucial and critical requirement from many companies right now, because you have to be able to see the same thing that you are looking at, if you want to do a design collaboration, you need to be able to point that 'okey, I want this thing changed' and if you are alone in a VR headset and trying to point at something and other people can't see, of course they look at the screen when you are pointing that but to be able to see the same thing and discuss about the same thing that is very crucial."
Partnership manager – Case company	• "I think it is extremely important and especially VR has been criticized that it isolates the person from the environment and closes the environment. Our mixed reality headset takes away some of those limitations that it is a lot easier to collaborate with other people but also with other technologies. So, if you can see your environment, you can use existing technologies like computer at the same time as you are using your headset. Now It is difficult to use the computer with the VR because you cannot see your keyboard and so on."
Clientele	How critical is the interconnectivity of two or more immersive technology products?
Group scientist – Client B	• "I think for longer term, it is critical, I think we know that where we want to be. Obviously, we have a lot of benefits as it is, but we are a global company." • "We will have to make a choice, which one person will see this. Everyone else can see it on the screen but we know that it is not the same. That is the whole reason why we are doing it on this kind of technology. So, having interconnectivity where you can have multiple people, then using it, then you get everyone experience it at same time which creates great conversation, it can create more ideas about where to go next, and more buying, because the more people try these things the more people get excited about and are more likely to be involved to support it whether financially or as an advocate person."
Senior technical lead – Client A	• "Up today I would say that it has not been that important because VR has not been used in a broader scale but since we are now implementing and we see VR as a natural extension of everything today that would be a key issue in the future I would say." • "We are of course looking into not only for reviews being able to look at the same object at the same time, and have the multiuser immersive experience that, of course, is a very important thing. But also the fact that the user is able to work with people in other places, we want to be able to have a review together with China office in a natural good way so that will be much more important and also different types of ordinary meetings like meeting VR type of applications."

Table 3. Exemplary interview responses barriers to adoption.

Partnership manager – Case company	• *"It depends on the industry, there are some factors that are industry specific and there are some factors that are across different industries I think apply."*
COO – Case Company	• "Well from company strategy perspective, our thesis has been that the relative underdevelopment of the systems to be used in industrial immersive computing, if you like, has been a barrier to adoption, i.e., the consumer devices simply are not capable of the kind of performance that would be needed for professional use of immersive technologies, and that is exactly the whole thesis behind Varjo's founding." • "Behind the capabilities of the systems themselves, which is what Varjo is changing is a barrier to adoption. Generally speaking, in addition to that, any frontier technology like Varjo's space is very depended on the overall technology advancement of particular industry or vertical." • "If we take a typical, let say government system integrator dealing with simulation in the military sector, the companies dealing in that space are typically technically very advanced, they have significant technical resources in-house at their disposal, and they are very comfortable, and kind of expecting themselves to be leading the adoption of new technologies rather than waiting for the market to mature, I mean, their whole DNA is build that way."
CMO – Case company	• "It is the fact that instead of looking at the monitor, the monitor is attached to your head. It's a combination of user experience, ergonomics and then the tools. Currently, most of the tools are designed for 2D screens and minority are designed for immersive experiences. As long as it is easier to boot up a computer and write thigs with a screen, that prevents this like 'all the time usage'. if you think like a scenario, where the physical screens are replaced with virtual screens, so that will take some time and get used to"
Interviewee	IQ: What are the biggest barriers to adopting immersive technologies in enterprises?
Senior technical lead – Company A	• "But actually, the performance of the available technologies has been one of the biggest obstacles because, I mean, if you work within automotive, you really need to be able to have superior quality." • "So, as long as the adopting really fulfill the expectations of the managers, they just think this is just another gadget that won't be useful at all." • "I think that there is a threshold in peoples mind that it is very hard, but in my view, I mean this is just another desktop, it is a screen basically. All the other things that is pretty hard to do like prepping the data, bring in all the functionalities and stuff like that. That is something that we have already in place. This is just another way to view the data we already have." • "But people, I do think that people have a mindset that it is complicated to use VR/AR applications and that is why we have been building VR/AR lab right now because we want to serve the rest of the company with this capability, in order to get people to started and see that it is not that hard really."
Group scientist – Company B	• "In terms of more immersive technologies focused, it is more how is this product really going to be that much better than what we are currently already doing and finding ways to prove that early on is key to get in any new technology. It is like having a learning period where you can try something out so we can kind of share it with key decision makers (…) and how we can use it wider in our company. Is there going to be potential to, if we develop the system that uses the hardware is that then going to take up by multiple other brands, regions and etc." • "Biggest barrier, previous bad experience."

Table 4. Exemplary interview responses for adoption decisions. End-user perspective.

Interviewee	*IQ: Could you describe your decision-making criteria when selecting new products before initial adoption and implementation?*
Senior technical leader – Client A	• "Of course, we always look at things from the perspective that it should add some type of value for the things we do here. We don't just bring in things because it is cool or latest's, it should be actually useful, it should be able to be spread at some point to more users than just like 2-3 people." • "But we always evaluate all new technologies that we take in, basically we always say that lets write NDA's and when we have done that we say we want to try your stuff for three months or something and then we do a lot of evaluation and if we find positive possibilities to add value in our process, then we start more close cooperation."
Group scientist – Client B	• "The key thing is looking at the technical aspects of why this is going to be better. It has to be enough to justify the warrant spending, x thousand more. It is not necessarily huge amounts of money when you look at the wider budget but for what it is, it is still reasonable amount of money. And we want to make sure that we are not just buying things for the sake of it. It has to be a significant technical step-up in areas that are important to us." • "The company itself, very important. We have had really bad experiences with companies in the past (…) and we want to make sure that the company is going to be around. So, if it looks like not just like buying a simple bit of kit and that's it, we take it. If it is a bit more than that it is always good to have a bit more like a partnership with that company one way or another." • "Future proofing, knowing that once you buy something there is potential to improve it in the future, is important."

Appendix 4. Nvivo codes – open and focused codes

Focused codes that emerged from the interviews. The codes were further interpreted and conceptualized.