



**Kaunas University of Technology**

School of Economics and Business

# **Role of Dynamic Capabilities in Addressing Technological Discontinuities in Hidden Champions**

Master's Final Degree Project

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Supervisor

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**Kaunas, 2022**



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Innovation Management and Entrepreneurship (6211LX031)

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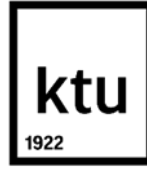
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**Kaunas, 2022**



**Kaunas University of Technology**

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## **Role of Dynamic Capabilities in Addressing Technological Discontinuities in Hidden Champions**

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### Summary

The technological discontinuities are challenges that incumbent firms in industries must overcome to sustain their position in the market. These discontinuities, which take place in form of technology cycles, happen at a faster pace in the high-tech industries increasing the uncertainty in the incumbent firms. In such fast-paced environments, the companies are required to have the ability to integrate, build, and reconfigure both the internal and external competences to address these rapidly changing environments if they want to keep their competitive advantage. When doing this, the Dynamic Capabilities (DCs), enable the firms to sense and seize new opportunities and transform or reconfigure. Moreover, in the context of the Hidden Champions (HCs) that are positioned in high-tech industries, despite being in these fast-paced environments, they are also positioned in narrow niche markets, which makes them even more sensitive toward external changes. In this sense, a research gap has been found in the studies performed on the topic of HCs, which despite their low brand awareness have a big impact on the national economies.

The **research aim** is to validate a conceptual framework of the role of the DCs in addressing technological discontinuities in HCs positioned in high-tech industries.

The **research objectives** are the following:

1. To get familiar with the concept of HCs and technological discontinuities in high-tech industry environments.
2. To perform a theoretical analysis to decompose the concepts of DCs, organizational rigidities, and technological discontinuities, and understand how they interrelate with each other.
3. To develop a conceptual framework for the DCs to address technological discontinuities in the specific context of high-tech industry positioned HCs, based on the previous bibliographic research.
4. To develop empirical qualitative research based on HCs positioned in high-tech industries to understand the role of DCs when addressing technological discontinuities in such fast-paced environments.
5. To provide a complemented and empirically validated conceptual framework for the role of DCs when addressing technological discontinuities in this specific context.

The **research method** includes the bibliographic research and analysis to build a first theoretical framework for the role of the DCs in addressing technological discontinuities in HCs positioned in high-tech industries. For the validation of this framework, a qualitative case study has been conducted in HCs positioned in high-tech industries in Lithuania, where semi-structured interviews have been conducted, and the information complemented with secondary data. For the validation and completion of the framework, qualitative content analysis has been performed by making use of *MAXQDA 2022*.

The **key findings** include a deeper knowledge of HCs and the key elements and interrelations between the concepts of technological discontinuities, organizational rigidities, and DCs. This enabled building a first theoretical framework for the role of the DCs when addressing technological discontinuities in this specific context. After the qualitative research, more insights have been gained regarding the interrelations of the concepts, and the previous theoretical framework has been completed and validated with the case studies. The importance of the DCs in addressing technological discontinuities has been confirmed in the context, where the main practices have also been identified. Nevertheless, despite both models' general fitting, there are discrepancies between the framework built based on theoretical research and the empirically validated model. Thus, apart from the key role of the DCs in these changing environments, the importance of including external sources and the value of the human resources has been recognized. Furthermore, the organizational rigidities have been characterized not as obstacles but as reinforcements to stay in the old technologies. Besides that, two different patterns of reaction have been identified depending on the proximity of the technological change to the expertise of the HCs.

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## Santrauka

Technologiniai pertūčiai - tai iššūkiai, kuriuos turi įveikti pramonėje įsitvirtinusios įmonės, norėdamos išlaikyti savo pozicijas rinkoje. Šie technologiniai pertrūkiai, vykstantys kaip technologijų ciklai, aukštųjų technologijų pramonės šakose vyksta sparčiau ir didina įsitvirtinusių įmonių neapibrėžtumą. Tokioje sparčiai besikeičiančioje aplinkoje įmonės, norėdamos išlaikyti konkurencinį pranašumą, turi gebėti integruoti, kurti ir pertvarkyti tiek vidines, tiek išorines kompetencijas, kad galėtų prisitaikyti prie šios sparčiai besikeičiančios aplinkos. Įmonės, naudodamos dinamiškus gebėjimus (toliau DG), gali atrasti ir pasinaudoti naujomis galimybėmis, transformuotis arba persitvarkyti. Be to, kalbant apie paslėptus čempionus (toliau PČ), kurie veikia aukštųjų technologijų pramonės šakose, nepaisant to, kad jie veikia tokioje sparčiai kintančioje aplinkoje, jie taip pat veikia siaurose rinkų nišose, todėl yra dar jautresni išorės pokyčiams. Šia prasme buvo nustatyta mokslinių tyrimų spragų, atliekant tyrimus, susijusius su PČ, kurie, nepaisant mažo jų prekės ženklo žinomumo, daro didelį poveikį nacionalinei ekonomikai.

**Tyrimo tikslas** - patvirtinti konceptualią sistemą, kurioje būtų apibūdintas dinaminių gebėjimų vaidmuo, sprendžiant paslėptų čempionų technologinių pertrūkių problemas aukštųjų technologijų pramonės šakose.

**Tyrimo uždaviniai** yra šie:

1. Susipažinti su DG ir technologinių pertrūkių koncepcijomis aukštųjų technologijų pramonės aplinkoje.
2. Atlikus teorinę analizę, apibrėžti DG, organizacinio nelankstumo ir technologinių pertūkių sampratą ir apibrėžti jų tarpusavio sąsajas.
3. Remiantis ankstesniais bibliografiniais tyrimais, sukurti konceptualią DG sistemą, skirtą technologiniams pertūkiams spręsti konkrečiame aukštųjų technologijų pramonės šakose esančių PČ kontekste.
4. Parengti empirinį kokybinį tyrimą, pagrįstą PČ aukštųjų technologijų pramonės šakose, siekiant suprasti DG vaidmenį sprendžiant technologinių pertrūkių problemas sparčiai besikeičiančioje aplinkoje.
5. Pateikti papildytą ir empiriškai patvirtintą konceptualią sistemą, skirtą DG vaidmeniui apibrėžti, sprendžiant technologinių pertrūkių problemas šiame konkrečiame kontekste.

**Tyrimo metodas** apima bibliografinį tyrimą ir analizę, siekiant sukurti pirminį teorinį pagrindą, skirtą DG vaidmeniui apibrėžti, sprendžiant PČ, esančių aukštųjų technologijų pramonės šakose, technologinius pertrūkius. Šiai sistemai patvirtinti buvo atliktas kokybinis atvejo tyrimas Lietuvoje esančiose PČ veikiančiuose aukštųjų technologijų pramonės šakose. Tyrimo metu buvo vykdyti pusiau struktūruoti interviu, o informacija papildyta antriniais duomenimis. Parengtai sistemai patvirtinti ir papildyti buvo atlikta kokybinė turinio analizė naudojant MAXQDA 2022.

**Pagrindinės išvados** apima gilesnes žinias apie PČ ir pagrindinius technologinių pertrūkių, organizacinio nelankstumo ir DG sampratų elementus ir jų tarpusavio ryšius, kas leido sukurti pirmąją teorinę sistemą apie DG vaidmenį sprendžiant technologinių pertrūkių problemas šiame konkrečiame kontekste. Atlikus kokybinį tyrimą, gauta daugiau įžvalgų apie šių sampratų sąsajas, o ankstesnė teorinė sistema buvo papildyta ir patvirtinta atvejo studijomis. Svarbus DG vaidmuo sprendžiant technologinių pertrūkių problemas buvo patvirtintas šiame kontekste, kuriame taip pat buvo nustatytos ir pagrindinės praktikos. Vis dėlto, nepaisant to, kad abu modeliai iš esmės tinkami, nustatyta skirtumų tarp teoriniais tyrimais sukurtos sistemos ir empiriškai patvirtinto modelio. Taigi, be to, kad šiose besikeičiančiose aplinkose pagrindinis vaidmuo tenka DG, buvo pripažinta išorinių šaltinių įtraukimo bei žmogiškųjų išteklių vertė svarba. Be to, organizacinis nelankstumas buvo apibūdintas ne kaip kliūtis, o kaip priemonė, padedanti išlaikyti senąsias technologijas. Be to, buvo nustatyti du skirtingi reakcijos modeliai, priklausomai nuo to, ar technologiniai pokyčiai yra artimi PČ turimam ekspertiskumui.

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## **List of abbreviations**

### **Abbreviations:**

ADC – Authorized Design Center

Assoc. prof. – Associate professor

B2B – Business-to-Business

DC – Dynamic Capability

Dr. – Doctor

Habil. – Habilitatus

HC – Hidden Champion

OI – Open Innovation

Prof. – Professor

R&D – Research and Development

SME – Small and medium-sized enterprise

## Introduction

### Relevance

The term Hidden Champions (HCs) was first used by Herman Simon in the 1990s when he analysed the export success of Germany's small and medium-sized world market leaders (Simon H., 1990). The HCs, which are known to be the leaders in niche markets, are characterized by having low public visibility. Nevertheless, and despite their low brand awareness, these firms are important in the national economies. Such is their potency in their specific markets that they outperform other nonhidden companies (Johann, M. S., Block, J. H., Benz, L., 2021).

In that respect, and even though the studies on the HCs were previously considered scarce, that is no longer the case. Their research has become a relevant field of study and within the last decade, it has been the focus of many publications (Schenkenhofer, J., 2022). Nevertheless, most of the publications take three main perspectives: the internationalization strategy, the R&D and innovation behaviour, and the geographic distribution, both worldwide and regional (Schenkenhofer, J., 2022). However, there is still a lack of qualitative and empirical research regarding how they approach technological discontinuities or turbulences in the narrow niche markets in which they are positioned.

### Problem

Technological discontinuities are challenges that incumbent firms in industries must overcome to keep their position in the market (Ehrnberg, E., 1995). Furthermore, the technology cycles become faster in the high-tech industries, which increases the uncertainty of the firms (Huang, P., Yao, C., 2018). In such fast-paced environments, organizational rigidities can be detrimental to companies, making the incumbent firms less responsive to change (Ansari, S. and Krop, P., 2012). In this regard, the companies will be required to have the ability to integrate, build, and reconfigure both the internal and external competences to address these rapidly changing environments if they want to keep their competitive advantage (Teece, D. J., Pisano, G., et al., 1997). These are the Dynamic Capabilities (DCs), and they refer to the ability of the firms to sense and seize new opportunities and transform or reconfigure (Teece, D.J., 2007).

In the context of the HCs that are positioned in high-tech industries, it must also be considered that these, despite being in these fast-paced environments, are also positioned in narrow niche markets (Simon, H., 1990). This characteristic makes them even more sensitive towards discontinuities. In this specific context, the research problem being approached in this study is based on understanding how the HCs that are positioned in the high-tech industries address technological discontinuities, and specifically, which is the role of the DCs when addressing these challenges.

The **subject matter of research** is to understand the role of the DCs in addressing technological discontinuities in HCs positioned in high-tech industries.

The **research aim** is to validate a framework to visualize the role of the DCs when addressing technological discontinuities, focusing on the specific context of HCs that are positioned in high-tech industries.

The **research objectives** set to achieve the proposed aim are the following:

1. To get familiar with the concept of HCs and technological discontinuities in high-tech industry environments.
2. To perform a theoretical analysis to decompose the concepts of DCs, organizational rigidities, and technological discontinuities and understand how they interrelate with each other.
3. To develop a conceptual framework for the DCs to address technological discontinuities in the specific context of high-tech industry positioned HCs, based on the previous bibliographic research.
4. To develop empirical qualitative research based on HCs positioned in high-tech industries to understand the role of DCs in addressing technological discontinuities in such fast-paced environments.
5. To provide a complemented and empirically validated conceptual framework for the role of DCs when addressing technological discontinuities in this specific context.

## **Methodology**

This research has been developed following the next steps. First, thorough theoretical research has been done to better understand the specific context of HCs. A deep analysis of the DCs, organizational rigidities, and technological discontinuities has also been done to decompose the concepts and acknowledge the interrelationship among them. Secondly, a conceptual framework has been developed to visualize the DCs and their role when addressing technological discontinuities. This framework has been built based on an extensive literature review and comparative analysis of different frameworks previously built regarding the DCs, and it has been adapted for the specific context of this research.

To further develop and complement the proposed theoretical framework, qualitative research has been designed and developed, for which the case study method has been applied based on high-tech HCs in Lithuania. In these case studies, semi-structured interviews have been performed with a professor and managers in strategic positions in the companies, who finely agreed on using their name publicly for the research. Furthermore, publicly available secondary data has also been used to complement the first-hand information obtained in the interviews. Following, qualitative content analysis has been performed using the MAXQDA 2022 software, which enabled to further validate and complete the proposed conceptual framework. Together with the results of the qualitative research, the final discussion regarding the role of DCs when addressing technological discontinuities in high-tech HCs in Lithuania is finally developed.

## **1. Problem Analysis**

### **1.1. Hidden Champions and Their Strategic Positioning: The Niche Market Strategy**

The term Hidden Champions (HCs) was first used by Hermann Simon in the 1990s when he analysed the export success of Germany's small and medium-sized world market leaders (Simon H., 1990). From then on, this term has been used to refer to small and medium-sized and generally family-owned companies that pursue a specific differentiation strategy: the niche market strategy. This strategy is the main characteristic that distinguishes them from the rest of owner-managed small and medium-sized enterprises (SMEs). More than 80% of them have also been shown to work as suppliers in the Business-to-Business (B2B) industries (Schenkenhofer J., 2022).

Nevertheless, from that description in 1990 until nowadays, more studies have focused on more empirical findings. As a result of these studies, are nowadays considered HCs the firms that meet these three characteristics: the firm must be among the top three in the ranking of its specific world market, its revenues must be less than €5 billion, and it must typically show low brand awareness, or low public visibility in the market (Simon H., 2012). However, these requirements may vary depending on the country or industry being analysed (Schenkenhofer J., 2022).

As mentioned, the HCs pursue a clear differentiation strategy focusing on specific niche market segments, in which they can concentrate their resources and get a dominant position not only locally but also worldwide (Venohr B. and Meyer K.E., 2007). In this regard, the fact that they are world market leaders is often a mere consequence of their niche market strategy (Schenkenhofer J., 2022). With this strategy, by offering knowledge-intensive products and technological advantage compared to the competition, they get a qualitative superior position, and therefore, they become the technology leaders. This superior position works as a barrier for other market entries and helps them keep the leading position. Such a position is obtained by investing highly in R&D and responding to the customers' needs through incremental and continuous innovation. For this aim, they keep close relationships with their customers worldwide, creating a high dependence and interaction rate among them (Audrestrch D.B. et al., 2018). Following this specific strategy and having the mentioned characteristics, the HCs obtain a leading position thanks to both technology-based product leadership and superior product quality with a focus on keeping close interactions with their customers (Zastempowski M., 2011).

### **1.2. The Fast-Changing High-Tech Industry**

When sustaining continuous innovation in the HCs that are positioned in high-tech industries, it is important to consider that in such emerging business fields, there is a lack of established market structure. This lack of structure is characterized by high uncertainty, not only related to the technological solutions being developed but also regarding the market structure and so also the actors that are part of the industry, together with the owned resources and contributions (Knight, L., Pfeiffer, A., 2015).

In these high-tech industries in which the pace of the technological change is fast, (as is the example of semiconductors, computer science, biology and chemistry, and other engineering sciences (Moretti, E., 2021), the strategic advantage is not only acquired by the correct management and deployment of the owned resources, but also by correct coordination of a network of partners (Rampersad, G., Quester, P., 2010). These high-tech industries are characterized by rapid changes in the product market, short life cycles, and fierce market competition. These make them high-risk industries in which the technical level of the company and the employees' knowledge are key aspects for keeping a competitive advantage and position. This increases the uncertainty of the companies positioned in these fast-changing industries, where the environmental and technological discontinuities happen in a faster cycle and thus are a source of high uncertainty (Huang, P., Yao, C., 2018).

### **1.3. The Effect of Technological Discontinuities on the Incumbent Firms**

As mentioned previously, the HCs are companies known for pursuing a specific niche market strategy, in which they acquire the leadership and “value leader” position by approaching a specific and narrow niche market (Venohr B. and Meyer K.E., 2007). This narrow strategy, however, makes them more sensitive towards discontinuities in their working market, and so forces them to keep constant track of the development of both the market and technologies and a close relationship with the customers, to keep their innovativeness and leadership position (Schenkenhofer J., 2022).

When talking about discontinuities, it is important to mention that there are various kinds of discontinuities. Technological discontinuities are critical in this regard. Technologies have been seen to evolve through periods where after some incremental changes, sudden technological breakthroughs are observed, which in fact, can either enhance (competence-enhancing) or destroy (competence-destroy) the competence of the incumbent firms in an industry. These significantly increase the environmental uncertainty (Tushman, M. L. and Anderson, P. 1986).

However, other kinds of market or political regulatory discontinuities can also directly affect the industries. In that sense, completely novel changes in the market, such as an emergence of new and appealing market segments or shifts in the political or regulatory environments where the companies are positioned can drastically affect the companies and their performance too (Bessant, J. 2005). As these discontinuous changes do not happen every day, the challenge of the firms is to be able to foresee them and be able to deal with them effectively, in such a way that these do not turn out to be detrimental and in the best scenario they are even able to take advantage of them.

This has been a challenge for incumbent firms throughout history (Christensen, C. 1997), as the emergence of innovations not only influences technology but also has implications on customer segments and their preferences and needs, the needs for complementary assets, business models, alliances, and networks and even in the whole architecture of the industry (Ansari, S. and Krop, P., 2012). In this changing environment, where technology is developing fast and competition is fiercer and more global, firms are forced to adapt to this dynamic market structure and keep innovating to obtain a competitive advantage and survive. In these conditions, innovativeness has been seen to be vital (Ince, H., Imamoglu, S. Z. et al., 2016).



When talking about changes in a company's environmental conditions, technological discontinuities or turbulences are a central force, as they completely shape appropriate organizational forms (Tushman, M. L. and Anderson, P. 1986). At the same time, they are also more critical in the high-tech industries, in which the company's performance and position in the market are highly conditioned by the technologies they own, and where these discontinuities induce bigger changes in such fast-evolving industries (Anand, J., Oriani, R., et al., 2010).

The effect of technological discontinuities in existing industries can result to be detrimental for established firms, intensifying competition or even creating a complete breakdown of the competitive patterns during a process of "creative destruction" (Schumpeter J.A., 1947). The concept of creative destruction refers to the situation where incumbents are found when facing discontinuous innovation, a situation in which the previous organization, structure, values, and norms may become rigidities and limit their ability to react and innovate (Bergek, A., Berggren, C., Magnusson, T., et al. 2013).

Technological discontinuities also play a significant role in the value of knowledge, were they rise the importance of the absorptive capacity and the knowledge creation capability of the firms (Zhou, K.Z., 2006). Moreover, having absorptive capacity is not always enough to overcome the challenges of technological discontinuities, and so companies must also be able to create new knowledge on their own rather than just relying on external acquisition from outside sources (Su, Z., Ahlstrom, D., et al. 2013).

When talking about technological discontinuities, two main types of shifts can be identified, competence-enhancing and competence-destroying discontinuities, depending on whether they enhance or destroy the existing competence or knowledge of the firms in the specific industry. Nevertheless, even if at different degrees, they are both sources of uncertainty for firms, as they always generate challenges for the current know-how of the company (Abernathy, W. J., Clark, K. B., 1985).

*Competence-enhancing discontinuities* are known to be initiated by the incumbent firms, bringing order-of-magnitude improvements in price or performance that build on the existing knowledge and skills within a technology or product class (Tushman, M. L. and Anderson, P. 1986). These innovations substitute previous technologies, but the required skills to master them do not become obsolete, this is, the previous know-how is still valid and useful for the company (Tushman, M. L. and Anderson, P. 1986). In this regard, they tend to reinforce the positions of the existing firms in the market, and they even increase the barriers for possible new entrants (Abernathy, W. J., Clark, K. B., 1985).

*Competence-destroying discontinuities* are known to be initiated by new firms and associated with increased environmental turbulence. These are innovations that require new knowledge and skills during the development of the product. Therefore, they are known to be destructive, as the previous necessary knowledge and competences to operate the previous core technologies are not relevant anymore (Tushman, M. L. and Anderson, P. 1986). In this regard, they tend to create major changes in the industry leadership and lower the barriers for possible new entrants, as existing competences become obsolete and the incumbents tend to be handicapped by the old technological paradigm (Tushman, M. L. and Anderson, P. 1986).

As far as what has been seen along with certain industries, technology seems to progress through stages of relatively long periods of incremental innovations based on competence-enhancing changes, and punctuated competence-destroying technological discontinuities, in which the periods of increasing consolidation and the learning-by-doing are challenged until they again, culminate in a dominant design and lead to the next incremental technological improvements. As technology also affects organizational adaptation, companies must be able to invest in R&D and technological innovation to shape the conditions of the environment in their favour. Those organizations that keep the ability to either create the technological change or adapt to it quickly, will be able to benefit from the first-mover advantages (Tushman, M. L. and Anderson, P. 1986).

#### **1.4. The Obstacle of Organizational Rigidities to React to Technological Discontinuities**

When talking about technological discontinuities, the threat and challenge reside in being able to identify or foresee these discontinuities and react to them. However, when companies collaborate closely with suppliers and customers and develop learning process routines under steady-state conditions of the environment, they sometimes struggle in situations of discontinuous shifts or the presence of radical innovations, where they may be unable to identify signals and effectively respond to innovation threats and opportunities (Bessant, J., 2005). Those capabilities sharpened during the periods of stability, the resource commitments and routines make incumbent firms less responsive to change (Ansari, S. and Krop, P., 2012). This is also what is called organizational rigidity (Dąbrowska, J., Lopez-Vega, H. et al. 2019).

Organizational rigidity is also regarded as the “success syndrome” or a consequence of past superior performance, to describe company culture and structures that are inert to change (Gilbert, C.G. 2005). Continuous success leads to path dependencies. When the superior technological competences become legitimized in the company, and the core capabilities turn into core rigidities, a change of trajectory becomes extremely difficult. Organizational rigidity is a way to explain how and why it is difficult and expensive to change company structures, routines, and contracts (Dąbrowska, J., Lopez-Vega, H. et al. 2019).

Two main types are identified: structural rigidity and capability rigidity. The first one refers to the firm’s internal and external organizational boundaries (Hannan, M. T. and Freeman, J. 1984) and the second one to the routines of the organization and the ability to explore and exploit knowledge (Gilbert, C.G. 2005).

##### **Structural Rigidity**

When talking about the structure, in the context of innovation, this refers to how the company can coordinate innovation internally, through different specialized R&D teams and well-controlled innovation processes, and externally, by managing external alliances and partnerships. The structural rigidity is then related to how the organization is formed, which affects how the ideas and innovations are managed, how are the internal relationships distributed (power and reporting) and how is the knowledge shared. The company's structure defines the organizational boundaries for the innovation activities, and which external or internal actors have an active part during which steps of the innovation (Dąbrowska, J., Lopez-Vega, H. et al. 2019).

Inside the structural rigidity, the internal structural rigidity refers to a team structure, organization or a chain of command that rarely changes or is rarely being questioned. External structural rigidity instead, is when even in presence of external collaboration there are rarely new adoptions, and the firm just relies on the collaborations or partnerships created over years. This influences the crossing of information through the boundaries of the organization, as if new knowledge is not shared from the inside of the firm to the outside or vice versa, the organization becomes increasingly rigid towards possible new opportunities (Chesbrough, H. W. 2003a).

Firm longevity and market success are two of the reasons for structural rigidity (Hannan, M. T. and Freeman, J. 1984). While companies grow and gain complexity, the company's structures start to get compartmentalized and rigid, making it more difficult for the knowledge to be transferred across the boundaries both internally and externally (Dąbrowska, J., Lopez-Vega, H. et al. 2019).

### **Capability Rigidity**

Regarding capability rigidity, this refers to the rigidity in different organizational routines or processes, and in how the exploitation and exploration of knowledge are conducted (Gilbert C.G. 2005). Capability rigidity is again built through path-dependency and by self-reinforcing mechanisms. Therefore, continuing success can lead to lock-in, leading to elevated levels of specialization and making it more difficult to transform routines. This can directly affect how both management and employees apply routines and how are exploitation and exploration developed (Dąbrowska, J., Lopez-Vega, H. et al. 2019). In that sense and considering the nature of the explorative and exploitative activities, capability rigidity leads to a tendency toward exploitation, and the absence of attempts for disruption (Dąbrowska, J., Lopez-Vega, H. et al. 2019).

The risk of developing organizational rigidity and the possible arousal of environmental turbulences as technological discontinuities force current companies, both large multinational and small and medium-sized enterprises, to think and work "out of the box" (Bessant, J., 2005).

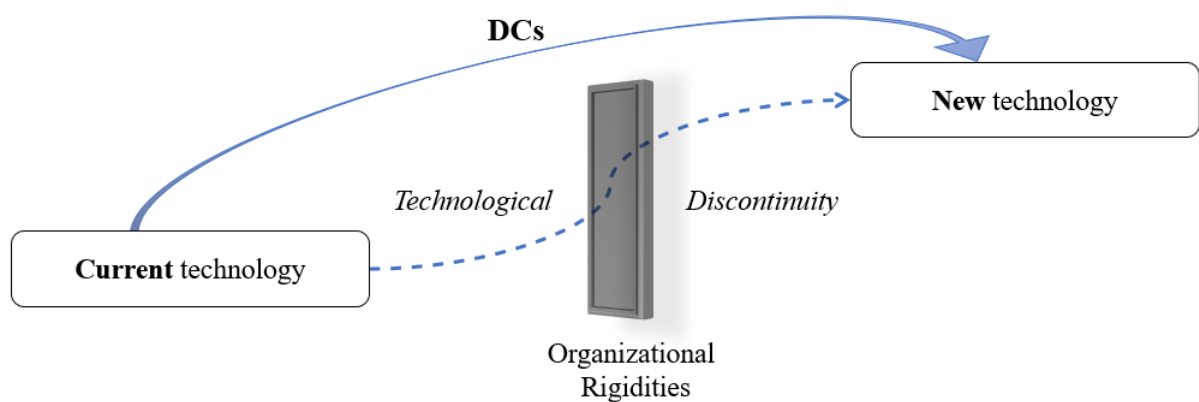
### **1.5. Dynamic Capabilities to Address Technological Discontinuities**

When being under the threat of possible technological discontinuities, the organizational rigidities (both the structural and the capability rigidities) serve as obstacles for the companies positioned in these industries (Bessant, J., 2005). Therefore, for years researchers and managers have been trying to identify which are the capabilities needed to sustain and support long-run business performance in an increasingly open economy with rapid innovation and a fast pace of discontinuities. In this regard, for keeping a sustainable competitive advantage it is important to own difficult-to-replicate assets, but also, dynamic capabilities (Teece, D.J., 2007).

Dynamic Capabilities (DCs) have been defined as „the firm's ability to integrate, build, and reconfigure internal and external competences and rapidly changing environments“ (Teece, D. J., Pisano, G., Shuen, A., 1997). In these rapidly changing environments, the winners in the industries are the ones that can prove timely responsiveness and rapid and flexible innovation, combined with the management capability to coordinate not only the internal but also the external competences (Teece, D. J., 1997). Therefore, the DCs are also suggested as „antidotes“ for the static perspective

of the resource-based advantage, in which the changing conditions may change the previously core competences into core rigidities (Leonard-Barton, D., 1992).

In this regard, it can be said that the DCs are relevant in achieving competitive advantage, especially in high-technology sectors, where the enterprise success depends upon the capability to adapt to the changing customer and technological opportunities, the ability to discover and develop opportunities by itself, to effectively combine internal and external inventions, to properly transfer knowledge and technology inside the company and amongst enterprises, and effectively upgrade the „best practice“ business processes, amongst others (Teece, D.J., 2007). The DCs are then key features in environments of fast technological pace as they will enable to keep sustainable competitive advantage (Teece, D.J., 2014). That way, the DCs will enable to react to possible technological discontinuities in the industries by overcoming organizational rigidities (Fig. 1).



**Fig. 1.** Visualization of DCs, organizational rigidities, and technological discontinuities.

When considering the concept of technological discontinuities, it must be emphasized that this is a practical challenge that companies have been facing throughout history, for which there is a long number of examples available. Among these examples could be mentioned the industry for semiconductor photolithographic alignment equipment, which went through four main technological challenges throughout its evolution. All four of these technological challenges created difficulties to react for the incumbent companies in the industry, making all of them lose their market shares from one generation to the other one (Henderson, R. M., 1988). However, this is not the only example available. Furthermore, other industries such as the mobile telephone industry and the automotive industry are empirical examples that illustrate how technological changes or discontinuities have disruptive effects on the industry structures (Ehrnberg, E., 1995).

Nevertheless, and even if research and studies have been done in the field of DCs till nowadays, there is still a gap in this research field related to the HCs. In this regard, several publications about DCs can be found from a variety of perspectives, such as the DCs based theory in the multinational enterprise (Teece, D. J., 2014; Grøgaard, B., et al, 2019; Altintas, G., et al., 2022), the DCs based theory in the SME (Grimaldi, M., et al., 2013; Eikelenboom, M., et al., 2019; Borch, O. J., et al., 2007), and also others that analyse its interrelation with other concepts, such as innovation, leadership, entrepreneurship, Open Innovation, and strategic management (Schoemaker, P. J., et al., 2018; Roundy, P. T., et al., 2019; Teece, D. J., 2020; Ambrosini, V., et al., 2009).

When researching the HCs, it must be mentioned that even if previously the research was scarce, it is nowadays not the case anymore (Schenkenhofer, J., 2022). The phenomenon of the HCs has been studied already from different perspectives and in different geographical locations. Regarding the geographical locations, some studies have been done not only in German HCs but also in Korea, China, Japan, Greece, and Denmark (Petraite, M., Dlugoborskyte, V., 2017). Additionally, the HCs have also been researched in Lithuania where it has been seen that because of the efforts to improve the local business environment its economy has become more attractive for this kind of company (Vaiginienė, E., Paulienė, R., and Urbšienė, L., 2021).

In all these research and studies, these companies have been approached from many different perspectives, focusing on their strong leadership, the global vision, the entrepreneurial behaviour, the organizational climate, the decentralization and delegation of authority to the people, the narrow focus and the intense specialization, the closeness to the customer, the outstanding and continuous innovation performance, the R&D intensity, and others, as it is well pointed by Monika Petraite et al., in their paper (Petraite, M., Dlugoborskyte, V., 2017). In general, and according to Schekenhofer, the earlier research done in the HCs can be classified in those that study whether their internationalization strategy, their R&D and innovation strategies, their geographic distribution, and others that are not assigned to any of these previously mentioned aspects (Schenkenhofer, J., 2022).

However, even if research has been done focusing on one or the other topic, referring to the research about DCs and the studies on the HCs and their characteristics, there is still a research gap when considering both concepts in combination. Thus, when analysing the importance of managing DCs in the HCs. In this specific area, it could be mentioned the paper from Daniel Wittenstein, in which the DCs of the HCs are analysed when reacting to the digital transformation, research which is done from a quantitative perspective and where it described that these companies emulate stronger DCs than other firms when facing the digital transformation in their industries (Wittenstein, D., 2020).

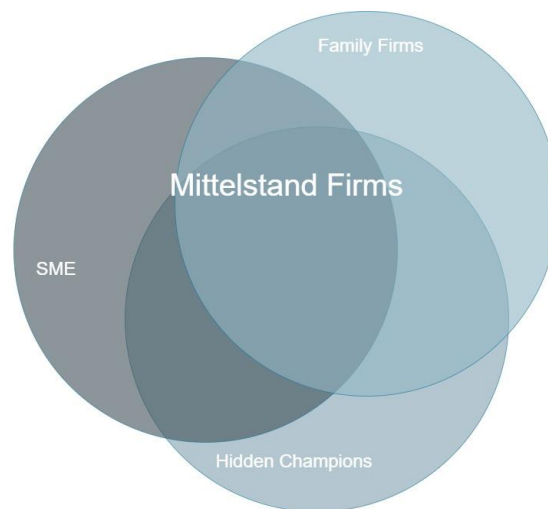
However, there is still a scarcity of research done about the HCs when considering the perspective of the DCs. It is important to consider that the HCs, and specifically the HCs positioned in the high-tech industries where they pursue the specific narrow niche markets, suffer from high uncertainty and fast pace of technological change, where also organizational rigidities may serve as obstacles when overcoming these technological discontinuities. To overcome these rigidities and be able to react to these challenges, managing DCs in these companies seems to be critical, as these may be key skills when supporting and sustaining long-run business performance and keeping a sustainable competitive advantage in fast-changing environments (Teece, D.J., 2007).

## 2. Theoretical Solutions

### 2.1. Hidden Champions: Innovation, Positioning, Internationalization, and Leadership

As mentioned in the problem analysis, even if the research done on the HCs was previously considered to be scarce, it is now not the case anymore. In this regard, during the last decade there have been many studies which focused on this specific kind of company, which have contributed to a detailed investigation of the phenomenon (Schenkenhofer, J., 2022).

Researchers have widely used the term HCs when referring to family-owned businesses, generally Small and Medium-Sized Enterprises (SMEs), which belong to the Mittelstand firms (IFM 2020a). This is how these different concepts have been linked to each other and misused over the years, using the concepts of family-owned firms, Mittelstand firms, and HCs interchangeably. However, it is important to make distinctions, as this work will be focusing on the HCs. In this regard, and as well mentioned previously in the problem analysis, the characteristic that distinguishes the HCs from the rest of family-owned SMEs, is their specific differentiation strategy, the niche market strategy. To visualize the relationship between the different concepts and show how each of the concepts also exists individually, the following Venn diagram depicts the associations between the family firms, SMEs, HCs, and Mittelstand Firms (Fig. 2) (Schenkenhofer, J., 2022).



**Fig. 2.** Relationship between the HCs, SMEs, Mittelstand firms, and Family Firms.

As previously mentioned, the term HCs was first used by Hermann Simon in the 1990s (Simon H., 1990) and since then, there have been research and studies done in this field. In these studies, the HCs are differentiated from the rest of SMEs and family-owned companies by pursuing this specific differentiation strategy, the niche market strategy (Schenkenhofer J., 2022). Apart from this, companies are characterized as HCs and differentiated from the SMEs when they meet the following three characteristics (Simon H., 2012):

- The firm is among the top three in the ranking of its specific world market.
- The revenues are less than €5 billion.
- It has a low brand awareness or low public visibility.

However, it is also true that these characteristics may vary depending on the country and field or industry being analysed, as the authors may adapt the definition to get a sufficiently large research sample (Schenkenhofer J., 2022). Apart from this, Simon Hermann (Simon H., 1996b) also characterized the HCs as sharing nine core characteristics formulated as imperatives (Table 1).

**Table 1.** The nine core characteristics of the HCs.

<b>The formulated imperatives</b>	
1	Set clear and ambitious goals
2	Define a market narrowly
3	Combine a narrow market focus with a global orientation
4	Be close to customers in both performance and interaction
5	Strive for continuous innovation in both product and process
6	Create clear-cut competitive advantages in both product and service
7	Rely on your strengths
8	Try always to have more work than heads
9	Practice leadership that is both authoritarian in the fundamentals and participative in the details

To better understand the context of this study, it is important to have a deeper understanding of the specific characteristics of the HCs. These can be listed as follows: the R&D and innovation strategy, the niche market strategic positioning, the internationalization strategy, and the leadership and management (Schenkenhofer J., 2022).

### **The R&D and Innovation Strategy**

The HCs supply mostly B2B markets with high-tech and knowledge-intensive products. In these specific technologically demanding niche markets, the innovation strategy is a key aspect to keep this leadership position. In these narrow and high-tech niche markets they have shown to focus on an incremental innovation strategy (Henderson R.M., Clark K.B., 1990). Nevertheless, these incremental improvements are built over a first radical invention which is later improved to satisfy the customers' needs and keep their loyalty (Voudouris I. et al., 2000). Therefore, the HCs are characterized for pursuing an innovation-based business strategy, based on incremental and continuous improvements over a first radical or breakthrough invention, where the market leadership is obtained because of their technological superiority and high customization (Rammer C., Spielkamp A., 2015).

In this regard, despite having large internal R&D investments, they also offer a higher level of innovativeness compared to other non-hidden competitors by creating strategic networks of their knowledge base and using methods as Open Innovation (Schenkenhofer J., 2022).

## **The Strategic Positioning: Global Niche Markets**

The HCs position themselves as “value leaders” for the high quality of products and services they offer and the high interaction with their customers. As mentioned, market leadership is obtained by pioneering new products or creating new market segments through radical innovations, which then are extended by continuous and gradual improvements. This specific strategy can be seen in traditional manufacturing sectors, in which incremental innovations are seemed to be more viable, for example, in industrial machinery and components, medical instruments, and automotive parts (Venohr B. and Meyer K.E., 2007).

This positioning is achieved thanks to a high resource commitment in R&D, sales, and distribution. First, the HCs spend 5% of revenues on R&D (Simon H., 2012). Second, they show a high commitment to customer needs by providing customer service and training through an owned distribution channel, a service network with sales and service subsidiaries. The needed information for the incremental innovations is also generated from this direct customer contact, where the personalized customer support service is one of the important parts of their value proposition. Third, the niche strategy allows them to transfer the developed industry-specific knowledge worldwide. In the B2B markets in which the customer needs are shared globally, the developed solutions for a customer in one place can be applied to another customer in another place in the same industry (Venohr B. and Meyer K.E., 2007).

## **The Internationalization Strategy**

The HCs restructure their portfolio to shift from a domestic to a global specialist strategy, a phenomenon called “global focusing” (Venohr B. and Meyer K.E., 2007). Because of the highly specialized demand of the selected narrow niche markets, they have shown to be able to serve other world markets with the same product (Witt A., 2015).

By following this strategy, they can also exploit their specific resources worldwide, by strengthening their capabilities with global operations (Venohr B. and Meyer K.E., 2007). Their market strategy then is a combination of both product specialization and geographic diversification. If the firm can offer differentiated and specialized products or services that appeal to a specific market segment, and their value chain is the one that better serves this targeted segment, the mentioned strategy may offer good returns and lead to a competitive advantage (Porter M.E., 1985).

Having global operations, such as serving multiple markets from one production site, having global supply chains and distribution networks, multiple research and development sites, and the exchange of the operational experiences also offer certain advantages. Among these advantages could be mentioned gaining economies of scale in production, cost advantages, and general enhancement of efficiency of their operations (Venohr B. and Meyer K.E., 2007).

The HCs thus build their competences for a specific industry, which can be transferable and competitive on a global stage. To obtain this operational effectiveness, they need long-term support and a focus on enhancing operations. Therefore, they emphasize the continuous improvement of their products and processes by having a close interaction with R&D and a high focus on the customer needs. This is achieved by international sales and distribution networks and selective offshoring with



aggressive cost management. In this respect, they show a global leadership ambition, where they search for emerging markets to pursue new large opening markets (Venohr B. and Meyer K.E., 2007).

### **The Leadership and Management Practices**

The market leader position of HCs is acquired by a family cooperative company culture accompanied by outside professional management. The strong innovativeness of these companies is attributed to the corporate culture. This is characterized by being decentralized, which helps to encourage innovation for higher involvement of the employees in the innovation process (Kaudela-Baum S. et al., 2014).

As mentioned, most of them are privately owned, a characteristic that shapes their whole organizational culture and proves the long-term development of business strategies. In the HCs, the capital-majority or the management is shared generally by family members or either one person, and the organizational structure follows a personal style, with informal communication channels and flat hierarchies (Venohr B. and Meyer K.E., 2007).

In that sense, the corporate culture could be defined as an “extended family,” with a strong internal connection and patriarchal features. Within the leadership, an important characteristic is the emotional attachment of the owners to the firm, which makes them strive for a multigenerational continuity and to stay independent. This creates a supportive environment for continuity of strategy. This is obtained by the development of both skills and assets, while also strengthening the value chain and creating a clear identity (Venohr B. and Meyer K.E., 2007).

To sum up, the management model of the HCs could then be summarized as a cooperative corporate culture in which the family ownership is complemented by a supplementary outside professional management. In this family environment, the positioning in strategic niche markets is then used to obtain a global market dominance by the exploitation and the enhancement of the resources and capabilities. In this respect, the HCs are also characterized by their continuous effort to increase their operational effectiveness to keep their competitive position (Venohr B. and Meyer K.E., 2007).

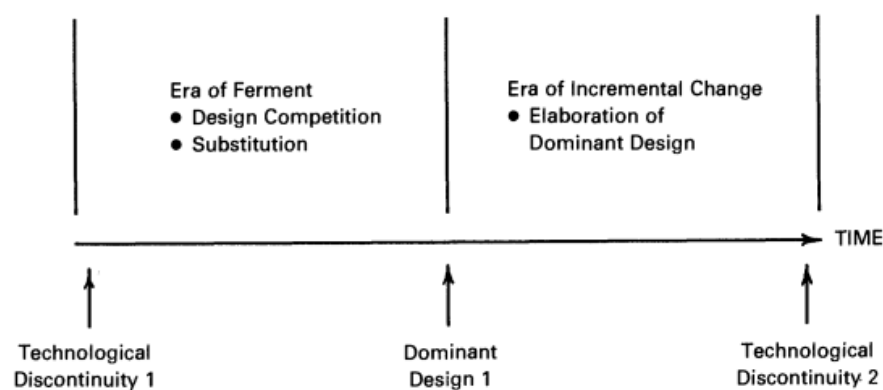
## **2.2. Technological Discontinuities in the High-Tech Industries**

Technological discontinuities or turbulences are as mentioned sources of high uncertainty in the industries, which are caused by sudden breakthrough innovations or slowly developing and disrupting innovations. Thus, technological discontinuities oftentimes have disruptive effects on the structure of the industries, which forces the established firms to adjust and adapt to the changes and the introduction of new technologies (Ehrnberg, E., 1995).

Throughout their research, authors have tried to find patterns of technological development in the industries. Among other studies, the work about discontinuous innovation by Tushman and Anderson in 1986 can be mentioned, in which they focus on the understanding of the implications of technological discontinuities. These argue that technological advances in products and processes are

not always incremental, and they are significantly interrupted by discontinuous innovations creating shifts in the development of the technologies and industries (Anderson, P. and Tushman, M. L., 1990).

Among the different models that have been created to explain the way how technologies evolve, the evolutionary model by Tushman and Anderson in 1986 shows how technological breakthroughs or discontinuities start an era of ferment, which is characterized by an intense technical selection and variation. This era of ferment, after tough competition and substitution among the companies positioned in the industry, ends with a single dominant design. Once this dominant design has culminated, a second era or period of incremental improvements will follow, characterized by the focus on technical improvements. However, regarding this evolutionary model, every era of incremental change can be always interrupted by a new technological discontinuity, which will open a new technology cycle (Fig. 3) (Anderson, P. and Tushman, M. L., 1990).

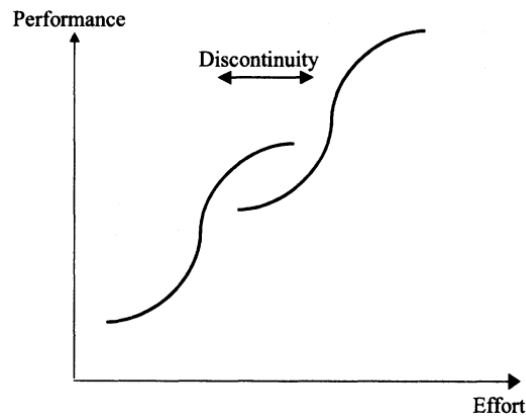


**Fig. 3.** Visualization of the technology cycle.

However, other authors have focused on not just how the industry and markets develop and evolve, but also on how incumbent companies react to the changes, how they foresee potential future challenges, how they innovate and mostly manage innovation, and how they gain competitive advantage by doing this. This was also called the “Innovator’s Dilemma,” by Clayton Christensen in 1997 when he tried to find the explanation for how even successful companies sometimes fail to predict the future and adapt to the changes in the technologies and the environment (Christensen, C. 1997).

In this regard, the authors agree that the effect of technological discontinuities in existing industries can be detrimental to established firms from different perspectives and in diverse ways. Thus, these technological discontinuities can be prejudicial for the incumbent firms for the intensifying competition, or even for the complete breakdown of the competitive patterns created by the process of “creative destruction” (Schumpeter J.A., 1947). This concept of creative destruction refers to the situation where incumbents are found when facing discontinuous innovation, a situation in which the previous organization, structure, values, and norms may become out-of-date and limit their ability to react to the changes and keep the competitive position (Bergek, A., Berggren, C., Magnusson, T., et al. 2013).

Experience shows that due to the technological discontinuities, no technological standard remains in an industry for an indefinite period (Abrahamson, E., Rosenkopf, L., 1997). Therefore, and as also well explained by Anderson and Tushman in 1990, when analysing the development of the technologies in an industry in a long-time horizon, a succession of standards can be observed. During this succession, the transition from the previous to the potential new standard happens in a dynamic manner (Carrillo-Hermosilla, J., Unruh, G. C., 2006). These technological discontinuities then can also be represented as a “jump” between the two S-curves of the competing technologies (Fig. 4).



**Fig. 4.** Representation of the technological discontinuity.

Therefore, technological discontinuities are important challenges that companies must react to if they want to keep their competitive position in the market. Nevertheless, and as has also been mentioned before, the pace of technological changes and discontinuities varies among industries. Managers in incumbent firms often need to change their strategy and structure at the right pace to respond to the demand of the rapidly changing and uncertain environments. In that regard, the fast-paced high-tech industries also form a higher uncertainty for these incumbent firms (Rtischev, D., Calen, R. 2003).

Accordingly, those high-tech industries such as semiconductors, computer science, biology and chemistry and other engineering sciences suffer from a fast technological change (Moretti, E., 2021). Therefore, there is increased uncertainty for the companies positioned in these industries, as both the environmental and technological discontinuities happen in a faster cycle than compared in other industries. This forces the companies to react to these challenges to keep their position in the market (Huang, P., Yao, C., 2018).

### **2.3. Organizational Rigidities as Obstacles for Firms**

Technological discontinuities are thus challenging for the incumbent firms in the markets. However, when facing these kinds of challenges and discontinuities, companies may meet different obstacles. Among these obstacles organizational rigidities are key features to be considered. Thus, rigidities are defined as “restricted information-processing capabilities and reduced control” by Soltwisch, B.W. in 2015, and it refers to two kinds of organizational rigidities, the rigidity in the presence of threats in the environment (Staw, B. M., Sandelands, L. E., et al., 1981) and the rigidity created in conditions of resource abundance (Soltwisch, B. W., 2015).

Concerning the organizational rigidities created by threats in their environment, the previous research refers to the loss of flexibility when dealing with changes in the industry. In these situations, the narrow perspective of the companies regarding the environment reduces the number of alternatives being considered when making decisions. This information-processing constraint that can be found at the individual, group, and organizational levels makes the companies more rigid in the way they react to the changes in the environment. Thus, it directly affects the organization's capacity to adapt strategically to the changing demands of the environment (Soltwisch, B. W., 2015).

Nevertheless, rapid growth and prosperity also create path dependencies in the companies, creating certain organizational paralysis and causing them to overlook decisive and potentially problematic changes or opportunities in the environment. In that sense, periods of rapid economic growth and success can be followed by a sudden decline, which can have a destructive impact on the organizations (Palmer, D., Maher, M., 2010). Firms may become less able to identify potential threats and less effective in responding to changing environments when they become dependent on their paths (Soltwisch, B. W., 2015).

Organizational rigidity can be related to the company structure or the company's capabilities, as well explained by Dąbrowska, J., et al. in 2019 and as mentioned above in the Problem Analysis. Accordingly, managers must be aware of the opportunities and threats that are present in the environment and make sure that they keep the flexibility to identify opportunities and make effective decisions, taking care of both the company's structure and capabilities (Soltwisch, B. W., 2015).

Hereof, when companies are positioned in industries presenting changes or turbulences, such as technological discontinuities in the fast-paced high-tech industries, the ability of the firms to react to these challenges and overcome rigidities is essential. Therefore, both threats and opportunities present in the environment may generate decision-making constraints and organizational rigidity. Hence, it is important that organizations and top management teams proactively combat the possible rigidities present in the companies (Barnett, C. K., Pratt, M. G., 2000).

#### **2.4. The Role of the Dynamic Capabilities in Fast-Changing Environments**

The Dynamic Capabilities (DCs) approach is a specific field in strategic management which aims to find an answer to the question: "by which sources and methods do private enterprise firms create wealth and capture value while operating in environments of rapid technological change" (Teece, D.J. et al., 1997). It aims to identify and visualize in which distinctive processes or better, capabilities, rests a firm's competitive advantage (Teece, D.J., 1997). The approach for the research is focused on the Schumpeterian perspective of innovation-based competition: the rivalry in the price and performance, the „creative destruction“ of existing incumbent competences, and the increasing returns (Schumpeter, J., 1934).

In this context, the aim is to dig deeper into the DCs approach to identify and visualize which are the firm-specific capabilities that are sources of advantage in comparison with the competitor, and how these capabilities or competences (together with the resources) can be correctly developed, deployed, and protected. In this respect, it can be mentioned that the DCs approach goes further than the resource-based perspective or „resource-based strategy (RBS),” as this strategy has often shown not to be enough to support a competitive advantage in the global competitive battles in the high-

technology industries. The ground of the DCs perspective is that the accumulation of a large stock of valuable technological assets (or other kinds of assets and/or resources) is not a sign of owning useful capabilities, and thus, may not be the way to gain competitive advantage (Teece, D.J., 1997).

DCs have been defined as „the firm’s ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments “(Teece, D.J., 1997). However, the speed of change in the environment is not as relevant as the prevailing degree of uncertainty (Teece, D., Peteraf, M. and Leih, S., 2016). Based on this definition, the DCs perspective emphasizes two distinct aspects that were not considered in earlier strategy perspectives (Teece, D.J., 1997).

The term “dynamic” refers to the ability or capacity of renewing the owning competences to achieve congruence with the changing environment. In these specific environments where there is high uncertainty and a fast technological pace (in which it is difficult to determine the future competition and market), certain innovative responses are needed in the companies. The term “capabilities” refers to the role of strategic management and its importance when appropriately adapting, integrating, and reconfiguring internal and external skills, resources, and functional competences to match the requirements of the rapidly changing environment (Teece, D.J., 1997).

Once the core definition of the DCs has been clarified, the different perspectives and frameworks that have been developed throughout their research are mentioned below, which enable a better understanding of the concept and its importance in the specific context of the HCs.

#### **2.4.1. Dynamic Capabilities and Strategic Management**

At a first sight, Teece D.J., Pisano G. and Shuen A., (1997), claimed that the competitive advantage of a firm resides in three main elements that affect its future performance: its distinctive processes (the way how the company coordinates and combines its processes), its asset position (the distinctive assets or difficult-to-trade knowledge and complementary assets of the company), and its evolutionary path (the historical path that the company has adopted or inherited throughout its development) (Teece, D.J., 1997).

In those industries where there is a rapid technological change, sharpening the internal technological, managerial, and organizational processes is essential for gaining a competitive advantage. This way, from the DC perspective, the essence of keeping a competitive advantage is more focused on the internal activities rather than strategizing based on the competitors or rivals. Teece D., Pisano G., and Shuen A. claimed that the competitive advantage of firms lies as mentioned in the three key elements (Teece, D.J., 1997).

The organizational and managerial processes refer to “how” things are done in the firm, and it alludes to the current routines and patterns of practice and learning. The specific asset position refers to “which” are the company’s current internal and external assets. And finally, the path refers to “what” is being done or what is the strategy being pursued, which refers to the strategic alternatives available to the firm, also considering the existence of path dependencies because of the company’s previous history and decisions (Teece, D.J., 1997).

## **Organizational and managerial processes**

Among the different processes the coordination or integration, the learning, and the reconfiguration processes can be distinguished. The coordination processes refer to the effectiveness of how the internal and external inputs are integrated into the firm (Aoki M., 1990). Thus, when considering the external sources, the importance of including external technologies and activities is claimed. These embrace the use of external alliances, virtual corporations, technology collaboration, and buyer-supplier relations, which are related to the concept of Open Innovation, and which will be further developed below (Chesbrough 2003a, 2006).

When referring to the learning processes, these are the operations by which the ability to better perform the tasks is achieved, by experimentation and repetition. This, nevertheless, does not only refer to improving the already known processes or technologies but also to identify new opportunities. Together with the coordination and learning processes, the reconfiguration processes enable the necessary internal and external transformation of the firm's asset structure (Amit R., Schoemaker, P.J., 1993). Company structures that support these processes facilitate better learning and coordination of opportunities, and their proper later transformation. This will provide the companies with a competitive advantage in times of environmental changes (Teece, D.J., 1997).

## **Positions**

When analysing the strategic advantage of a firm it is also important to consider which are its specific assets. These can be internal assets, such as specific endowments of technology, intellectual property, customer base, or complementary assets. And external assets, which are more related to the interactions with suppliers and complementors (Teece, D.J., 1997).

When considering the asset position, the goal is to create value and gain a competitive advantage. When competing against other firms, ownership protection and the use of technological assets are relevant differentiators. Also, when these technological assets require the use of other complementary or related assets, the ownership and protection of these assets are relevant. In that sense, the organizational boundaries and therefore the vertical, lateral, or horizontal integration of the company is crucial when coordinating the owned technological and complementary assets. Additionally, the amount of money available to the company for investment, which is determined by the cash position and the degree of leverage of the company, is as well a key asset. Furthermore, the availability of this financial asset will have a significant implication on the performance of the company (Teece, D.J., 1997).

Among the intangible assets, reputational and structural assets can be mentioned. The reputation of a firm shapes the responses of customers, suppliers, and competitors towards it. Moreover, the innovativeness of an organization and the way how the competences and capabilities co-evolve in it are highly related to the company's structure. Thus, the structure of the organization, whether this is formal or informal, and its external linkages are influencing factors (Argyres, N.S. 1995). Furthermore, the different organizational governance also supports different types of innovation (Teece, D.J., 1997).

When considering the company's position, the market position and institutional aspects are features to be contemplated. The institutions and public policies directly enable or constrain what a company can or cannot do. Examples of this can be regulatory systems, intellectual property regimes, and antitrust laws. As such, the market position is a key influencing factor, as it shapes the possible opportunities available for the company in the future (Teece, D.J., 1997).

## **Paths**

As mentioned, not only the asset position and organizational processes determine a firm's competitive response to the environment. The earlier historical path of the firm and the technological opportunities that are available, also influence the company's performance and response in times of change (Teece, D.J., 1997). By path dependency, the tendency of a firm to go in one direction is shown. In the same way, how the current position of a company is shaped by its earlier history and experience, the future available paths will also be highly influenced by its current position and the possible paths ahead. This can be also understood as the „history“ of the company in which the past shapes the future. As an example, the firm's previous investments and developed routines constrain its current position and future decisions (Teece, D.J., 1997).

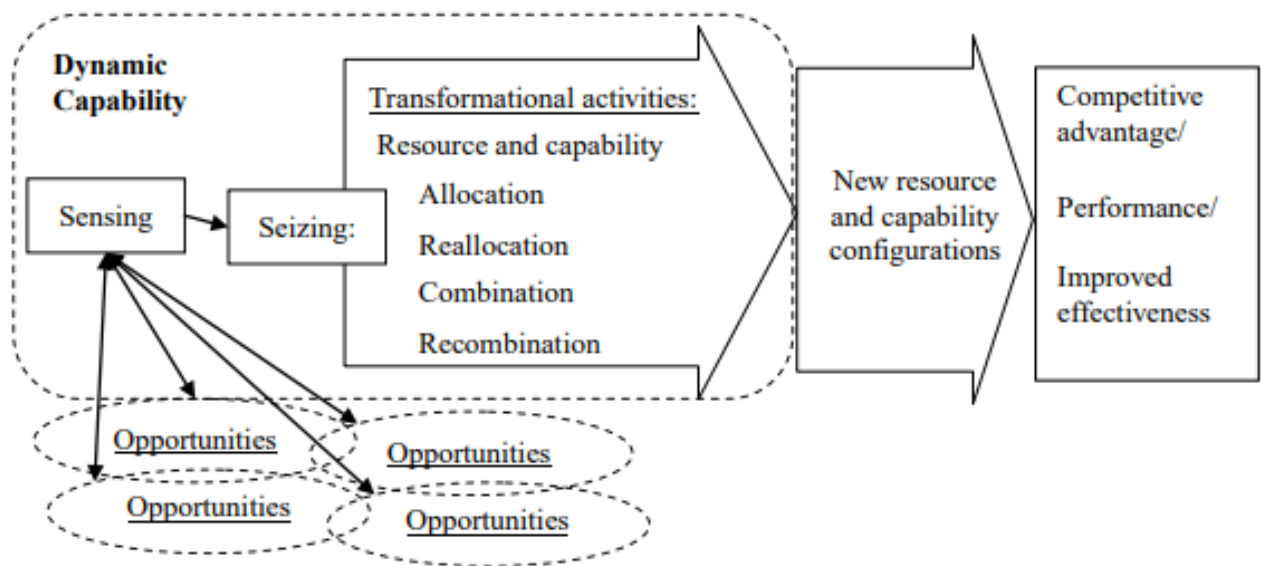
Nevertheless, the choice of technological opportunities that are available to the company also shapes to a certain extent the path that this will follow in the future. This will at the same time be conditioned by the ability to create its technological opportunities, which to a certain extent is the result of the basic research activities being pursued and the creation of scientific breakthroughs. At a company level, the creation of new technological opportunities will depend on its innovativeness. However, the acquisition of external opportunities depends on the organizational structures and how these link the universities and other institutions that are engaged in basic research (Teece, D.J., 1997).

### **2.4.2. Dynamic Capabilities and Sustainable Business Performance**

After Teece D.J., Pisano G., and Shuen A. introduced the concept of DCs, David Teece, later dug deeper into this concept, where he did not only identify DCs as key elements for achieving a sustainable competitive advantage or superior long-run business performance in the fast-changing, open, and dynamic economies, but he also developed further in their microfoundations (Teece, D.J. 2007). When going deeper into the microfoundations of DCs, these are referred to as the skills, procedures, processes, organizational structures, decision rules, and disciplines that undergird the enterprise-level sensing, seizing and reconfiguring capacities, which are difficult to develop and deploy. For their easier analysis, the DCs are disaggregated into the following three capacities (Teece, D.J. 2007):

- The capacity to sense and shape opportunities and threats.
- The capacity to seize opportunities.
- The capacity to combine and reconfigure the firm's intangible and tangible assets when necessary.

DCs thus, enable companies to adapt to the technological opportunities and the changing customer environments, keeping their flexibility and enabling them to adapt and even change the ecosystem they are in. A simple visualization of the sensing, seizing, and transformational DCs is shown below, which is based on the ideas of Teece D.J. in 2007 (Fig. 5) (Eriksson, T., 2013).



**Fig. 5.** Overview of the DCs framework based on Teece D.J. 2007.

Teece, D.J. however, went deeper into the DCs framework and explained the sources for the enterprise-level competitive advantage over time. According to him, the basis of the concept of DCs is that the enterprise’s success depends upon several characteristics, which include the detection and development of new opportunities; the effective combination of internally and externally created inventions; not only efficient but also effective technology transfer inside and between and amongst enterprises; the protection of intellectual property; the improvement of “best practice” processes; making unbiased decisions; the invention of new business models; protecting against possible imitation and other forms of replication. This success also involves shaping the new “rules of the game” in the global marketplace“ (Teece, D.J. 2007).

### **Sensing (and Shaping) Opportunities and Threats**

The sensing includes the identification, development, and calibration of technological opportunities, customer needs, and possible strategic challenges (Teece, D.J. 2020). The sensing capability is an activity of scanning, creating, learning, and interpreting where the investment in research is necessary for its complementation. This, of course, is of higher importance in industries or environments in which there is a fast pace of technological change or the fast creation of new technological opportunities (Teece, D.J. et al. 1997). The sensing activities, therefore, include not only the control of internal existing information and knowledge but also the search for external new knowledge that can create new opportunities (Schumpeter, 1934).



However, the sensing capability does not only require the ability to identify opportunities but also to assess how these opportunities may change the landscape of the industry, and how the competition, customers, and suppliers will respond (Teece, D.J. 2007). Analytical systems enable to learn, sense, filter, shape, and calibrate opportunities (**Error! Reference source not found.**). Among these can be mentioned the processes to select new technologies, the ways how to direct internal R&D, and processes to make use of supplier and complementor innovation. Additionally, the ability to learn about the developments being done in exogenous science and the capability to identify changing customer needs and target market segments are also essential for firms (Teece, D.J. 2007).

The discovery and creation of new opportunities depend to a considerable extent on the individuals' knowledge and capabilities, on the ability to scan and monitor internal and external technological developments, and assess customer needs, which may be both expressed and latent. Thus, the sensing capability requires not only learning but also interpretative and creative activities. The success of the sensing capabilities lies in putting in place organizational processes which will create and nurture new technological information (internal or external), tap developments in exogenous science, monitor the competitor activity and customer needs, and shape all these to later create new opportunities (Teece, D.J. 2007).

### **Seizing Opportunities**

The firm's seizing capabilities are those which determine the ability of an organization to respond to the previously identified opportunities and threats. These include investing decisions to commercialize innovative technologies, identifying and filling existing capability gaps, and designing and implementing business models (Teece, D.J., 2017b). Therefore, the seizing capability is the activity of addressing the new technology or market opportunities that have been sensed, which is related to investments for the later development and commercialization activities. When deciding to invest, the company's resource commitments may also differ depending on its existing position in the market (Mitchell, W., 1991). When seizing new opportunities and making investment decisions, there may be the need to overcome diverse kinds of biases, such as the bias of loss/risk aversion. The quality of the enterprise's routines, decision rules, strategies, and the leadership that evaluates the potential new opportunities are key features when overcoming these biases (Teece, D.J. 2007).

The decision of when, where, and how much to invest goes together with selecting and creating a business model that will define the commercialization strategy and investment priorities. Thus, at this step, not only technological knowledge is needed but also a good understanding of the institutional and organizational design. When seizing opportunities, the ability to delineate the customers' solutions and the right business model will be important. The business model will not only determine how the company delivers value to the customer but will also define the technologies being used in the product or services offered, the customer segments that are being targeted, the revenue and the cost structure and therefore, how the company will capture value (Chesbrough, H. and Rosenbloom, R.S., 2002).

Apart from defining the business model, seizing the opportunities also requires the establishment of clear enterprise boundaries and the selection of decision-making protocols. First, essential elements for establishing enterprise boundaries to manage complements are, for example, the appropriability regime, the specific phase of the industry development, and the relative position of both the innovators

and imitators regarding the complementary assets needed. Second, the design of the organizational structures and selection of decision-making protocols is a way to encourage change in the firms. In the process of incentivising creative action, building loyalty and commitment among the employees of the company also increases the performance of the enterprise. When building and nurturing this commitment and loyalty among the employees, the firm's top management plays a key role. Therefore, the company's leadership is an essential element when making quality decisions, correctly communicating the values and goals, and motivating the employees in the firm (Teece, D.J. 2007).

In those industries where there is a rapid technological change, the decision-making process may require skills that are not homogeneously distributed among the responsible individuals. This will then require appropriate communication and information transfer among the different departments and hierarchy levels. Furthermore, making investment decisions at the project and enterprise level is challenging, as there is a need to make judgements and make decisions under uncertainty regarding various aspects such as the future demand, the competitive responses, and the payoffs from the investments being done (Teece, D.J., 2007).

### **Managing Threats and Reconfiguration**

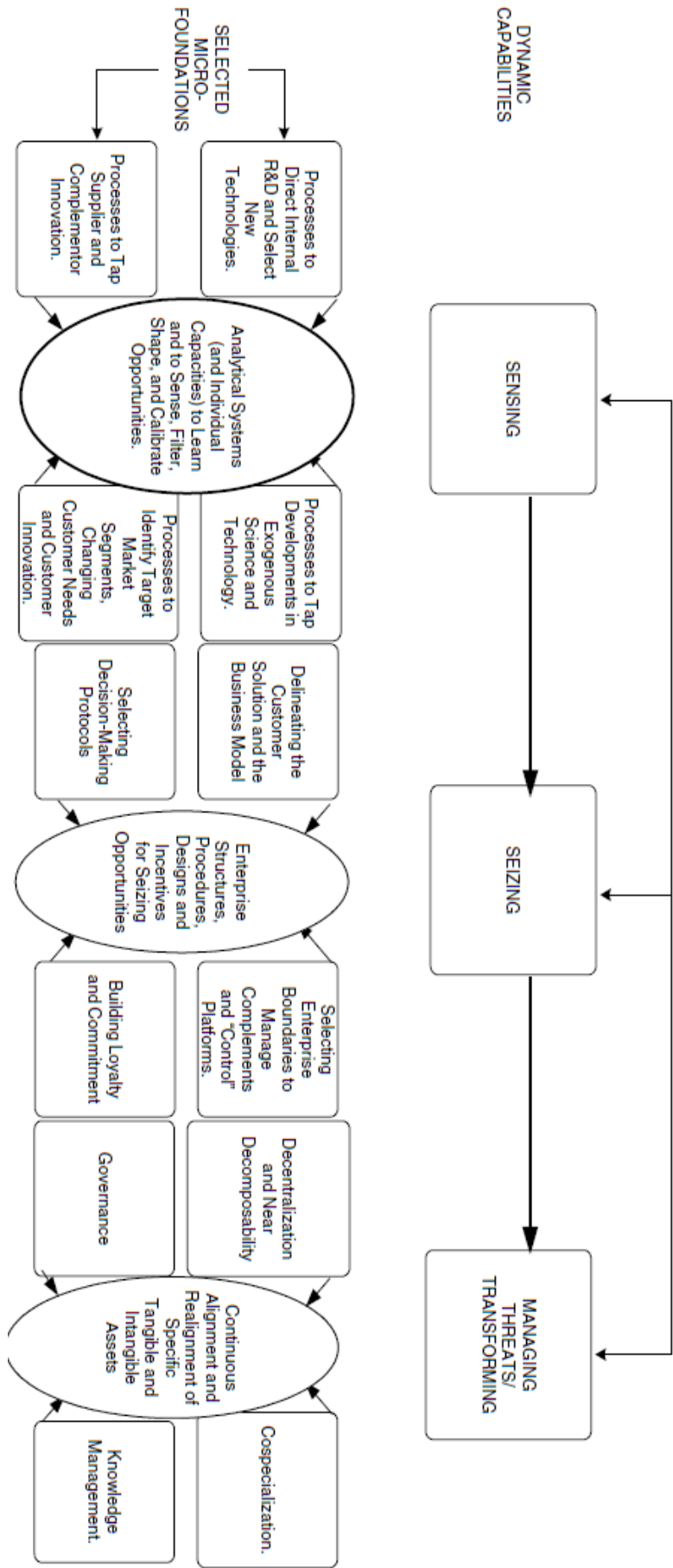
After successfully identifying and calibrating the opportunities, correctly selecting the technologies, and committing the resources to investment opportunities, these may lead to enterprise growth and profitability. However, the enterprise growth and success might have the risk of leading the company to develop in a path-dependent manner. Thus, a key aspect to sustain profitable growth in the firm is to keep the ability to transform and reconfigure while the enterprise grows and as the markets and technologies change. Transformation at the right pace will be the key capability for avoiding path dependencies (Teece, D.J., 2007).

In this regard, the reconfiguring or transforming capabilities are more related to the asset orchestration to keep the different elements of the organization internally coherent, aligned with the strategy, and competitive concerning the external environment. For the continuous alignment and realignment of the company's assets, the decentralization is a key element to mention, which will include the adoption of loosely coupled structures to avoid structural rigidities, and the development of integration skills to coordinate both internal and external factors. This decentralization is also strictly related to the governance mode of the company, which is responsible for the alignment of the incentives and the minimization of complications (Teece, D.J., 2007).

Among the transformation and reconfiguration capabilities, knowledge management is also essential when reacting to threats. Thus, it is important to correctly manage the learning processes, the transfer of knowledge and the acquisition, and the interaction of the company's know-how, together with its protection. Additionally, a strategic fit will also be required to enhance the value of the combinations of assets which is also referred to as cospecialization. This can refer to the fit of the assets among each other, the fit between the strategy of the company and the structure, or the strategy and the processes being conducted in the firm. In this regard, the investments into the cospecialized assets are important DCs, and they require the ability of the top management to identify the needs and the opportunities to invest in them (Teece, D.J., 2007).

To sum up, in the following framework the DCs (sensing, seizing, and transforming) are shown as foundations for gaining a competitive advantage in environments of rapid technological change (Fig. 6). In the same way, the past, also referring to the followed path, will have an impact not only on the current situation but also on the future performance (Teece, D.J., 2007).

By owning and correctly managing these capabilities, companies will not only gain sustained competitive advantage but will also be able to shape the competition and the marketplace outcomes by the semi-continuous orchestration of assets, business reconfiguration, and innovation. This framework emphasized the organizational and managerial competences that first, bring competitive advantage to the companies, and then enable to continuously adapt and transform to maintain this in such economies that have a rapid technological change (Teece, D.J., 2007).



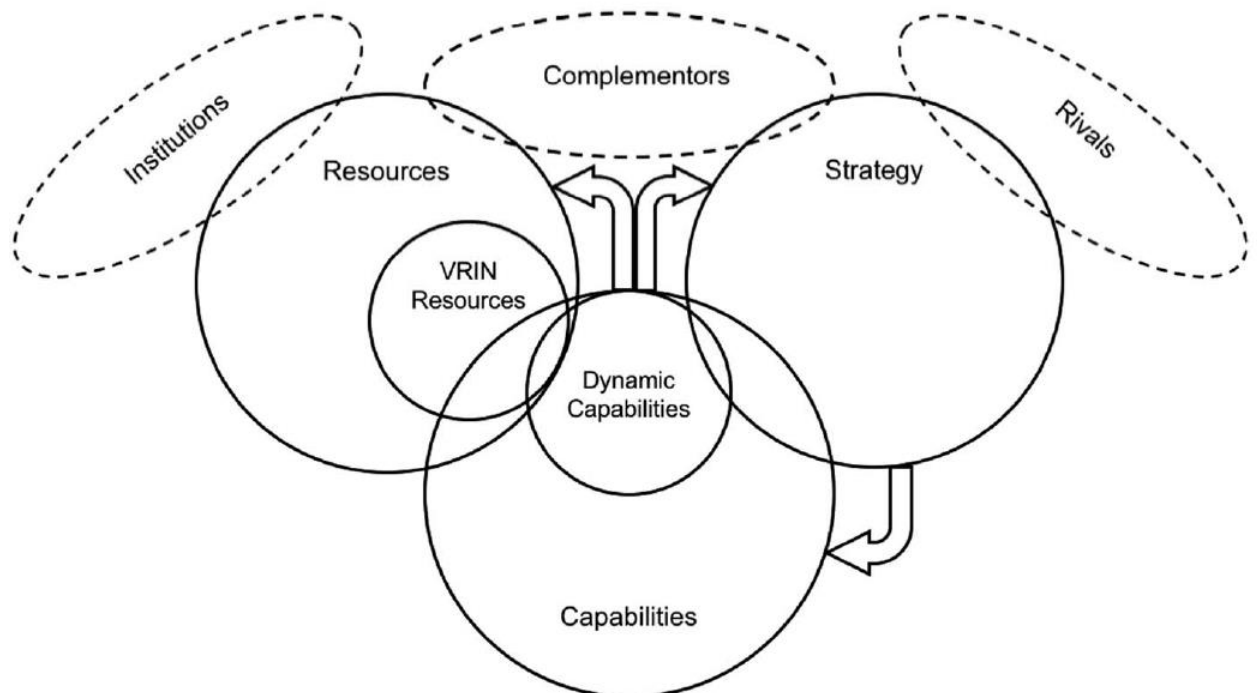
**Fig. 6.** Foundations of DCs and business performance.

### 2.4.3. Dynamic Capabilities as Management Systems Theory

Once the concept of DCs has been presented in-depth, it is also relevant to have a broader perspective of the concept and its interrelationship with other key elements when it comes to gaining a competitive advantage in fast-paced environments. In that sense, the systems theory approach enables one to have a broader perspective of the concept of DCs, paying more attention to the relations of the various interdependent factors that altogether determine the competitiveness of a firm (Simon, H. A. 1962). In this specific context, when considering DCs as a source of competitive advantage, it is also important to consider that these are part of a system together with the firm's resources and strategy, which all together determine and shape the final competitive advantage towards its rivals (Teece, D.J. 2017a).

Therefore, the systems theory considers organizations as social systems which are made of different sub-units that need to harmoniously inter-relate to build an effective organization. This complementarity of the elements and their integration is also considered to be key to the outcomes of the company (Johnson, R. A., Kast, F. E., and Rosenzweig, J. E. 1963). However, each of the elements of the system can also be disassembled into sub-elements and analysed in detail, as is the case of the DCs (which can be broken down into the microfoundations, and the sensing, seizing, and transforming DCs, as described in the previous sub-chapter).

To approach the DCs from a broader perspective, the DCs framework is shown as a system and complemented with other components such as firm resources, the firm's strategy, and external participants (Fig. 7). In this figure, the dashed border indicates those factors that are external to the organization, and the arrows indicate a major influence among the elements. The VRIN resources refer to the valuable, rare, imperfectly imitable, and non-substitutable resources, which will be later mentioned (Teece, D.J. 2017a).



**Fig. 7.** Key elements of the DCs framework from the systems perspective.

Regarding the previous framework, the capabilities are interconnected with the resources and the strategy of a firm, and they constitute a system that collectively determines the competitive advantage of a firm. On the one hand, the capability hierarchy is at the core of the framework, and this is composed of the ordinary capabilities (those that are required to conduct the current business but do not necessarily help to achieve a long-term advantage) and the DCs. These second ones can be also divided into the lower-level DCs or microfoundations (those that allow the firm to integrate, reconfigure, or subtract resources including DCs (Eisenhardt, K. M. and Martin, J. A., 2000)) and higher-level DCs (the sensing, seizing, and transforming activities that enable to maintain external fitness). These highest order capabilities are the ones on which the top management of a company must be most focused, as they are the most important to address the problems and the opportunities the company aims to solve or exploit (Teece, D.J. 2017b).

On the other hand, the resources include the assets of the company which can be both tangible (employees, equipment, buildings) or intangible. Here, the key resources will be the VRIN resources (valuable, rare, imperfectly imitable, and non-substitutable) resources, the ones that support sustainable competitive advantage (Barney, J.B., 1991). Regarding the strategy instead, this will focus on outmanoeuvring competitors and leveraging in-house strengths by carrying on preceptive diagnoses to identify obstacles, guiding a policy that specifies how to overcome these, and building a coherent plan for the implementation of the policy (Rumelt, R., 2012).

To sum up, and as it is well visualized in the framework, because of the interdependencies between the capabilities, resources, and the strategy, it is important to consider all these three elements, as they all contribute to the sustainable competitive advantage of a company in respect to its rivals (Teece, D.J. 2017a).

#### **2.4.4. Dynamic Capabilities and Open Innovation**

Open Innovation (OI) has been defined as the access and the exploitation of the outside knowledge and the release of the internal knowledge and expertise for other 's use (Chesbrough, H.W., 2003a). This external knowledge can be accessed in diverse ways and to different degrees, starting from the possible informal contacts with the customers or suppliers, to formal contracts for external development of the technologies or R&D alliances (Chesbrough, H., wicker, S., 2014). When studying the DCs and the different elements that influence them, it is also important to consider how OI relates to this framework and how can this enrich management at a firm level. In that aspect, also when talking specifically about technology management, which is of special interest in this research (Teece, D.J. 2020).

Several features in the industries and markets have forced the companies to search for external ideas and resources, apart from developing their R&D activities. Examples of these features are the faster pace of technological change and the increasing global competition, which are making the product life cycles to be shorter. At the same time, the multi-disciplinary nature of innovations and the necessity to master multiple diverse technologies in short time frames are also the reasons why firms tend to search for external knowledge. This way, firms create network types of organizations to support each other not only for technological but also for other purposes (Friar, J., Horwitch, M., 1985). This way, OI includes processes for creating networks and collaborative research among firms and other institutions as an addition or complement (or even substitute) for in-house R&D activity (Teece, D.J. 2020).

OI can be considered as a set of processes conducted by the companies or firms, while the DCs include more than just processes, such as aspects related to the corporate governance, the decision-making, and the various sources for competitive advantage (Teece, D.J. 2020). However, considering OI in a firm can highly enrich the DCs approach to the management, and at the same time, securing the company's DCs makes the OI approach more successful. Thus, these two concepts also go together when it comes to gaining a competitive advantage in a company when reacting to technological discontinuities. In this regard, the use of OI can strengthen a firm's DCs by increasing its ability to learn about new technological opportunities and to make use of external resources to later fill capability gaps (Teece, D.J. 2020).

### **The Effect of OI on the DCs**

As mentioned before, both concepts are mutually reinforcing each other. Therefore, the use of OI enables to broaden the horizons for sensing and seizing new opportunities. When considering the sensing capabilities, the openness to the external knowledge sources enables a richer and deeper technological and market understanding by the firms. Thus, connections with universities and their researchers or other institutes may enable them to solve specific problems and provide a view of new potential future developments (Teece, D.J. 2020). In this sense, a broad-based external search and its integration with customers, suppliers, and complementors can be an important source of information for firms. Thus, making use of this external knowledge can be a source of durable competitive advantage (Teece, D.J. 2020).

Concerning the seizing of opportunities, openness can help a company fill capability gaps and build new ones. For this, different methods can be applied depending on the strategic importance of the capabilities being missing, such as outsourcing or the acceleration of the process of capability development in those cases in which there is a need to control the trajectory of the technology (Teece, D.J. 2020). Nevertheless, the opening of innovation will also enable to redeploy the internal resources from those that are non-core technologies to be sourced externally, which will enhance the flexibility of the company to focus on other core competences or resources (Teece, D.J. 2020).

### **The Effect of the DCs on the OI**

Strong DCs also enable the application of effective OI practices. Having strong DCs in the firm will enable a better choice, government, and monetization of the OI initiatives. In this regard, having orchestration skills, the ability for sensemaking, and a correct organizational design will facilitate effective OI practices. Having the ability to coordinate the different activities and assets along the company's innovation ecosystem requires excellent orchestration skills. Thus, these orchestration skills also go together with the right governance, which will enable to manage the relationships properly and successfully with external partners (Van de Vrande, V., Lemmens, C., et al., 2006). Besides the governance, the organizational design will be the one that will enable the appropriate information transfer along with the different departments and employees in the firm, so that the relevant information gets where it must be managed and accurately assessed (Teece, D.J. 2020).

Moreover, in conditions of ambiguity and high uncertainty, the ability for sensemaking is also important for an effective OI practice. In that sense, the sourcing of technologies must be done in such a way that will first enable to make sense of different possible conflicting signals. This will facilitate the process of decision making and will enable to address the future in a judicious manner (Teece, D.J. et al., 2016).

In general, DCs will enable the better coordination of decisions among the different firms that are part of the network (Leiblein, M.J., Reuer, J.J., et al., 2018). The orchestration of assets, the management of the activities across different organizations, and the integration of different technologies are important capabilities that will also contribute to creating value (Teece, D.J. 2020). However, attention must be paid to complications that may arise from practising OI. In this sense, open knowledge sharing, and different alliances may induce contractual issues. Therefore, strong DCs will also be required when managing these issues that arise from increasing the external sources and knowledge sharing (Teece, D.J. 2020). The following table (Table 2) shortly shows how having strong capabilities in a company can make OI more effective.

**Table 2.** The effect of strong DCs on OI.

SENSING	RECOGNIZING external know-how OPPORTUNITIES
	LEARNING from external sources of know-how
SEIZING	AGILE DECISIONMAKING once an external source is identified
	INITIATING COMBINATORIAL ACTIVITIES
	ADOPTING hybrid BUSINESS MODELS
TRANSFORMING	SELECTING GOVERNANCE MODE for external linkage
	INTEGRATING internal and external knowledge

## 2.5. Dynamic Capabilities in the Context of Technological Discontinuities

The DCs enable to address rapidly changing environments by integrating, building, and reconfiguring both a firm's internal and external competences (Teece, D.J., 1997). In this respect, turbulent environments, such as environments with frequent technological discontinuities, create incentives for companies to employ and make use of these DCs to reconfigure themselves and pursue new opportunities (Van den Bosch, F. A., Volberda, H. W., and De Boer, M., 1999). As these turbulent environments create discrepancies among the current optimal technologies, knowledge, and capabilities, and the ideal operational capabilities, the need for a reconfiguration in the firm enhances the value of the DCs (Fredrickson, J. W., Mitchell, T. R., 1984).

In such conditions of change, the self-reinforcing dynamics in the firms and the path-dependent behaviours create rigidity and resistance to change, where different phenomena, such as the emotional attachment to the past success, can turn the previous core values into core rigidities in the organization (Miller, D., 1992). In this sense, the presence of rigidities in companies should function as an alert to make them reconfigure, transform, and make the outdated and rigid capabilities more flexible to again bring competitive advantage to the company (Suddaby, R., Coraiola, D., Harvey, C. et al., 2020).



Thus, having proper DCs is of high importance in fast-changing environments, such as the high-tech industries, where the technological changes happen at a faster pace than in less complex industries (Huang, P., Yao, C., 2018). In this respect, the DCs are more relevant in such environments that display specific characteristics, among which can be mentioned environments that are exposed to both the threats and opportunities of rapid technological change and those where the technical changes are systemic, meaning that a variety of inventions are combined when creating the products or services developed. These are characteristics that are found in high-technology sectors (Teece, D.J. 2007).

To gain a sustainable competitive advantage in these fast-moving environments, a firm will need not only difficult to replicate assets and knowledge but also difficult-to-replicate DCs, which will be the ones that will enable to create and keep the company's asset base continuously (Teece, D.J., 2007). This requires overcoming the company's possible rigidities, which requires strong management and a good strategy. Overcoming a company's narrow search horizon requires a huge effort, as because of path dependencies the firm tends to get attached to the previously established problem-solving competences (Teece, D.J., 2007). Errors in organizational decision-making processes can be especially damaging as there are fewer opportunities to recover from mistakes (Nelson, R. R., and Winter, S.G., 2002). In this sense, those companies that are not able to transform and reconfigure and that frame the future in a manner limited to the company's current knowledge, will most probably not succeed when trying to address new opportunities, even when they can recognize them (Teece, D.J., 2007).

Then, it will be a combination of different DCs, skills, features and characteristics of the firms and their management which will enable them to survive, evolve, and correctly address the possible opportunities in such fast-changing environments. This ability to adapt and react to the changes will provide them with a sustainable competitive advantage, and thus, a possible long-term survival (Teece, D.J., 2007).

## **2.6. The Integrated Framework of the Role of Dynamic Capabilities in Addressing Technological Discontinuities in the Hidden Champions**

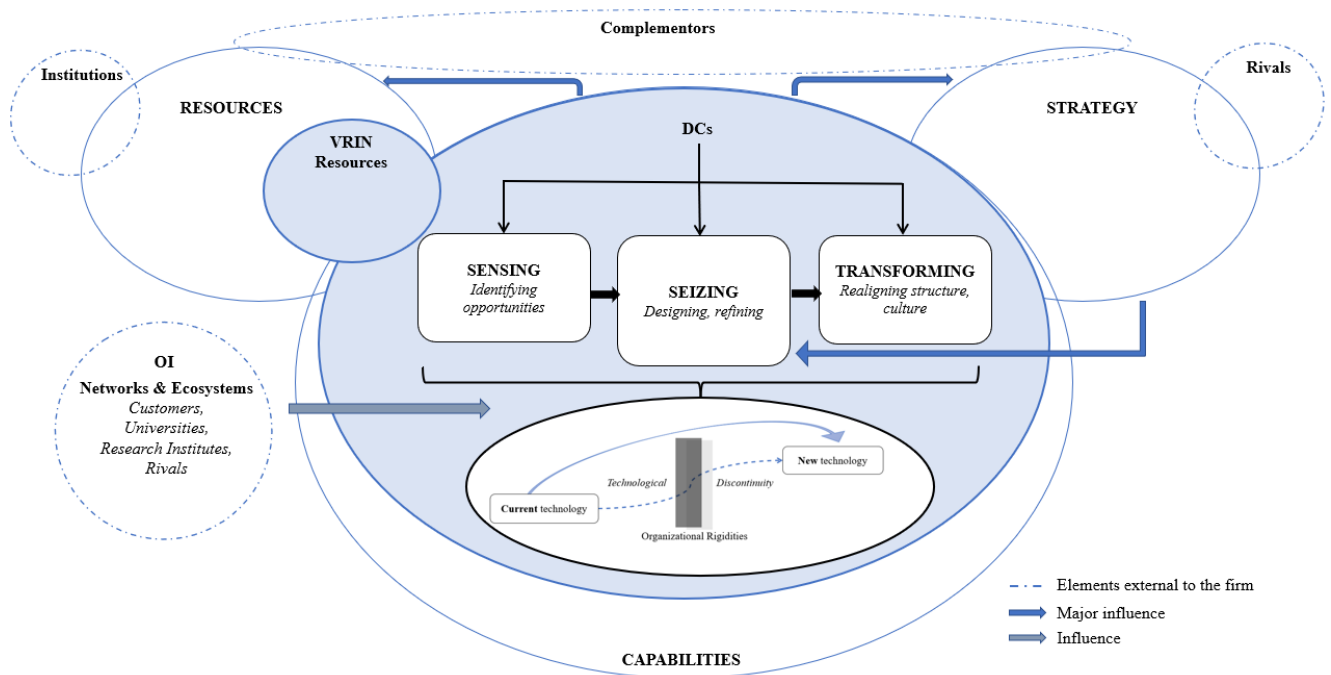
When developing a framework for visualizing the role of DCs to address technological discontinuities in the specific context of the HCs, the different frameworks created by Teece D.J. along with his research about the DCs have been considered. In this regard, by building this framework, the objective is to visualize the relationship between the different interrelated elements mentioned above. The focus, then, is on developing and validating a conceptual framework that will enable to represent the relationship of the different specific variables that are key in this context and visualize how these interrelate with each other from the company perspective.

The research done by Teece D.J. has been thoroughly analysed and studied, for which the frameworks previously developed by this author have been disassembled and assembled again for proper suitability. As such, for the development of the framework, the following interrelated elements have been considered, as can be also seen in the figure: the companies' DCs, resources and strategies, and the influence of external actors or OI (Fig. 8). When building the model, apart from the DCs, the strategy and resources of the firm have also been included, as these are distinctive features of the HCs (Schenkenhofer, J., 2022). Furthermore, the influence of other elements and participants that are

external to the firm also needed to be included, as is the case of the rivals in the firm, the institutions, possible complementors, and other external features or components that may influence the company’s development and performance. These external elements in the framework are depicted by dashed borders.

At last, and as has been emphasized previously, the proposed model has been built specifically around the challenge of the technological discontinuities, and the phenomenon of the organizational rigidities, which can serve as obstacles when reacting to this challenge. In that sense, and by building this model, the aim is to depict the whole phenomenon in the specific context of the technological discontinuities, where based on this framework, the DCs will enable to overcome this obstacle and react to the challenge. When doing this, other elements as the company strategy and resources will also be relevant.

To sum up, and as is visualized below, the main elements of the framework are the resources (VRIN resources), the specific strategy of the company, and the DCs: the sensing, seizing, and transforming capabilities, together with the practices of OI. The abilities to anticipate technological change (sensing), the ability to motivate organizational change (seizing), and the reconfiguration or exploitation of new activities (transforming), are required by a firm to react to technological discontinuities caused by the emergence of a new technology. And to overcome the structural inertia or organizational rigidities (Fig. 8) (Suddaby, R., Coraiola, D., et al., 2020).



**Fig. 8.** The role of DCs in addressing technological discontinuities.

The proposed framework of the DCs in this specific context is divided into four key elements: the resources, the strategy, the DCs, and OI. In this model, the objective is to visualize which different elements have an effect and interrelate with each other when the HCs confront the challenge of technological discontinuities and thus, need to overcome possible organizational rigidities.

## **Resources**

When analysing how the HCs overcome the challenge of technological discontinuities, as also mentioned by Teece D.J., Pisano G., and Shuen A. (1997), are referred to as resources the tools or assets that the company has in hand. This includes financial, technological, complementary, structural, or institutional assets, among others. From the number of different resources in the firms, the VRIN resources, this is, those that are valuable, rare, imperfectly imitable, and non-substitutable, are the ones expected to be of the highest value, and the ones providing a competitive advantage concerning the rivals or competitors positioned in the same market (Teece, D.J. 2017a).

## **Strategy**

When considering the strategy, the special and distinguishing feature of the HCs is being considered: their specific niche market strategy. Thus, when reacting to environmental challenges such as technological discontinuities in the industries, the company's strategy is a key feature to consider in this context. When talking about strategy, the company's historical path and future opportunities are included. The previous historical progression not only constrains the current position but also the future behaviour of the firm. The strategy, moreover, directly affects the seizing DCs and the market approach of the company, as the technological opportunities available to the firm will be also key elements that will shape its current and future position (Teece, D. J., 1997).

Then, the strategy will highly depend on a good understanding of the specific market segment and niche being approached. The HCs are known to have a higher level of innovativeness for their extensive knowledge of the specific market and a clear focus on where to innovate (Din, F. U., Dolles, H., et al., 2013). In addition to that, the HCs have shown to have a clear focussed strategy also for customisation, making them even better than larger incumbents of the market, as the bigger players may even ignore the market opportunities identified by the smaller players (Simon, H. 2009). In this regard, the search for and settlement in narrow niche markets that have previously not been colonized is a special feature of the Hidden Champion's strategy (Schenkenhofer J., 2022).

## **Open Innovation (OI)**

When breaking the structural rigidity of the company, OI is an important feature that provides organizational transformation, as the knowledge flows, together with the internal and external structures of the company, play a significant role in the level of innovativeness (Enkel, E., Gassmann, O., et al., 2009). This transformation comes from combining internal and external ideas, technologies, and information, which are key to keep the innovativeness of the company (Radziwon, A., Bogers, M., 2019). In this regard, OI, however, comprises not only the outside-in (technology acquisition or exploration) but also the inside-out (technology exploitation) movement of knowledge and technologies (Lichtenthaler, U., 2008). With the technology exploitation, or the purposeful outflows of knowledge, the innovation activities leverage the internal technological capabilities outside the organizational boundaries. In reverse, the technology exploration, or the purposive inflows of knowledge, refer to those innovation activities that are performed to capture external knowledge (Lichtenthaler, U., 2008).

When focusing on the HCs, it has been seen that the ability to efficiently make use of their external networking in SMEs is one of the reasons for their success compared to the other larger competitors in the market. These external resources are used to shorten the innovation time, reduce both risk and cost, and increase the flexibility of their operations. This inter-firm collaboration is especially important for companies with limited complementary assets to leverage the developed technology externally (Lichtenthaler, U., 2005). In this aspect, the type of OI being pursued by SMEs seems to be more the technology exploitation type for the market opportunities, by collaborating with another firm specialised in marketing which executes the market exploitation, market test, and analysis of the customer needs, for example (Rothaermel, F. T. and Deeds, D. L., 2004). For technology exploitation, SMEs usually enter the supplier-customer relationship with large firms and create strategic alliances or outsourcing agreements with other firms to create value (Edwards, T., Delbridge, R., and Munday, M., 2005). However, innovative SMEs also make external networks with universities, research establishments, or other SMEs (Lee, S., Park, G., al., 2010). It is also mentionable that when talking about OI, the right organizational culture and the correct top management are essential for good functioning (Din, F. U., Dolles, H., et al., 2013)

### **Dynamic Capabilities (DCs)**

When referring to the DCs, the specific sensing, seizing, and transforming capabilities of the HCs are considered, especially those that enable the companies to overcome possible existing rigidities in times of technological discontinuities.

#### Sensing Capability

The sensing capabilities refer to the identification, development, and calibration of opportunities, which among other strategic challenges are also the technological opportunities (Teece, D.J. 2020). Among the sensing capabilities, the following specific ones can be mentioned in the case of the HCs in this context.

#### *Processes to Direct **Internal R&D** and Select New Technologies.*

When sustaining continuous innovation in firms, the acquired external knowledge must also be combined with the internal innovation activities. When developing these innovations, the absorption of new knowledge and its integration are key aspects, together with the creativity and the ability to create innovative ideas. As a result, the creativity of the idea will directly influence the innovativeness of the product (Moorman, C., and Miner, A. S., 1997). In that respect, when talking about managing internal R&D in the company, the innovation focus (whether it is more radical or incremental innovations) and the learning focus (whether it is explorative or exploitative) will help to identify opportunities and technologies of different nature.

In such a way, radical or incremental innovations will differ in their respective novelty (Dewar, R. D., and Dutton, J. E., 1986), and the explorative or the exploitative focus will differ in the closeness of the knowledge needed to develop the innovation from the company (Corso, M., Pellegrini, L.

2007). To gain a competitive advantage in the company in fast-changing environments, it is important to consider the company's objectives and strategy to define, establish, and develop the learning and innovation focus of the firm (Corso, M., Pellegrini, L. 2007). The correct management and allocation of resources will enable not only to satisfy today's customer needs but also to identify new opportunities and anticipate those needs of tomorrow's customers (Corso, M., Pellegrini, L. 2007). In times of technological discontinuities, both the absorptive capacity, the capability for knowledge creation, and the interaction among both aspects will be important when overcoming challenges (Su, Z., Ahlstrom, D., et al., 2013).

#### *Processes to Tap Supplier and Complementor Innovation.*

When sensing and identifying new opportunities, the close relationship with the customers and the emphasis on approaching the customer's needs is one of the most important external stimuli for innovation in the HCs. This close relationship has been seen to be an important driver for constant innovation, both incremental and radical (Din, F. U., Dolles, H., et al., 2013). This successful innovation also seems to depend on the interaction with other external actors (Chesbrough, H. W. 2003). In this regard, suppliers may also positively affect a company's innovation performance, such as in the new product development, product quality, and product and production cost and development time (Din, F. U., Dolles, H., et al., 2013).

#### *Processes to Tap Developments in Exogenous Science and Technology.*

As previously well mentioned, the use of OI and thus, the use of external sources is important when reacting to technological discontinuities. To be able to tap the developments being done in the exogenous science and technology, when either the need knowledge or the solution knowledge is located outside the company's boundaries, the absorptive capacity of an organization plays a key role to absorb and make use of this knowledge (Schweisfurth, T. G., and Raasch, C., 2018). The absorptive capacity of a firm can be defined as the ability of an individual to identify, assimilate, and make use of external knowledge for innovation and exploit it for commercial ends (Cohen, W. M., and Levinthal, D. A., 1990). This then is also a source of competitive advantage, as it has a positive relationship with product innovativeness (Su, Z., Ahlstrom, D., et al., 2013).

When developing such absorptive capacity, the company's prior related knowledge will enable a better understanding of the new upcoming technologies, which will depend on the individual absorptive capacity of each of the members that compound the firm. In this regard, this will also determine the transfer of information between distinct functions inside the company, such as R&D, manufacturing, production, and sales. Having shared expertise is necessary for proper communication (Mansfield, E. 1968).

The absorptive capacity will also indicate the capacity that a company has to make new associations. As a result, the absorptive capacity of a firm will also determine the ability of its R&D to acquire and exploit external knowledge. This will determine to which extent can this external knowledge be applied, and new technological opportunities identified and exploited (Cohen, W. M., and Levinthal, D. A., 1990).

## *Processes to Identify Target Market Segments, Changing Customer Needs, and Customer Innovation.*

When identifying new opportunities in the market, it is also important to consider the market and the specific customer needs. As such, the HCs are known not just for approaching the specific niche strategy, but also for keeping the technological leadership and a high innovative level, creating a close customer relationship to address their needs. In this regard, innovativeness is essential for gaining competitive advantage and it is a driver for long-term success, as is the enabler to responding to today's environmental challenges in the market (Baden-Fuller, C. 1995). In this challenge, it is not enough to focus only on the current customers, but it is also necessary to consider the needs of tomorrow's customers (Boer, H., Gertsen, F. 2003).

### Seizing Capability

This is the ability to respond to the identified opportunities or threats. Thus, this will include the capabilities of the HCs as making investment decisions to commercialize innovative technologies, identifying, and filling existing capability gaps, and designing and implementing correctly business models (Teece, D.J., 2017b). Among these, defining the correct decision-making protocols will also be a key capability when it comes to reacting to challenges such as technological discontinuities.

There are size-specific characteristics that make smaller firms more responsive, for example, having fewer layers in the organisational hierarchy, having more open boundaries, more adaptability to change, and shorter and more efficient channels for internal communication with a higher ability to establish partnerships. For example, smaller firms in the high-tech industry have shown to have higher levels of dynamic innovation performance. In that sense, the small size of the HCs makes the teams work closely, being more flexible, adaptable, and with a faster R&D and innovation (Din, F. U., Dolles, H., et al., 2013). However, firm size may have a diverse impact in different circumstances, such as the case of the low technology products (where the necessary core knowledge is easier acquired), in which larger companies appear to have a higher ability to commercialize new technologies, as they own more resources (Eggers, J. P., Park, K. F., 2018).

### Transforming Capability

Finally, and when it comes to reacting to challenges such as technological discontinuities, not only the successful identification and calibration of the opportunities and the correct selection of the technologies provide a competitive advantage in a company, as then, these may have the risk to grow in a path-dependent manner (Teece, D.J. 2007). Thus, being able to reconfigure and transform itself, will also be a key element, mostly when talking about addressing technological discontinuities.

Regarding the transformation capability in the HCs, different elements can be mentioned as key aspects when reacting to the challenge of technological discontinuities. In this aspect, features such as the organizational structure (decentralization), the governance, and the knowledge management (knowledge transfer, know-how interaction...) can be essential. When talking about formal and informal organizational structures, the first seems to be effective for incremental innovations and the second instead, for radical innovations (Menguc, B., Auh, S. 2010). By contrast, the HCs, even if

they commonly have informal or organic organizational structures, seem to have advantages towards both radical and incremental innovations (Simon, H. 2009). In this sense, the standardisation, teamwork, and communication culture make them suitable and able for both kinds of innovations (Din, F. U., Dolles, H., et al., 2013).

When talking about organizational structure, it must be however considered that as the markets or environments change because of technological turbulence, for example, the adequate or the suitable strategy and structure for a firm may also change. Those structures that enable adaptation will be the successful ones in times of discontinuities (Eggers, J. P., Park, K. F. 2018). Strong leadership is also an important determinant for the innovation capacity, as in the HCs innovation is a top management responsibility in the initial stages (Simon, H. 2009). An integrative leadership style where the leaders provide challenging goals and a clear vision has a positive effect on the creativity of the employees and therefore also on their performance (Din, F. U., Dolles, H., et al., 2013). Therefore, a way to increase the innovativeness in a company is to delegate responsibilities and develop a common vision to reduce internal resistance (Simon, H. 2009).

As such, it has been seen that when managing many layers of an organization, both the rules and the systems being used tend to create structural rigidities, which influence the technological responsiveness of the company. Accordingly, decentralization is the way to sustain DCs, as this brings the top management closer to the new technologies and closer to the market and the customers themselves (Teece, D.J. 2007).

### **3. Research Methodology**

#### **3.1. Research Design**

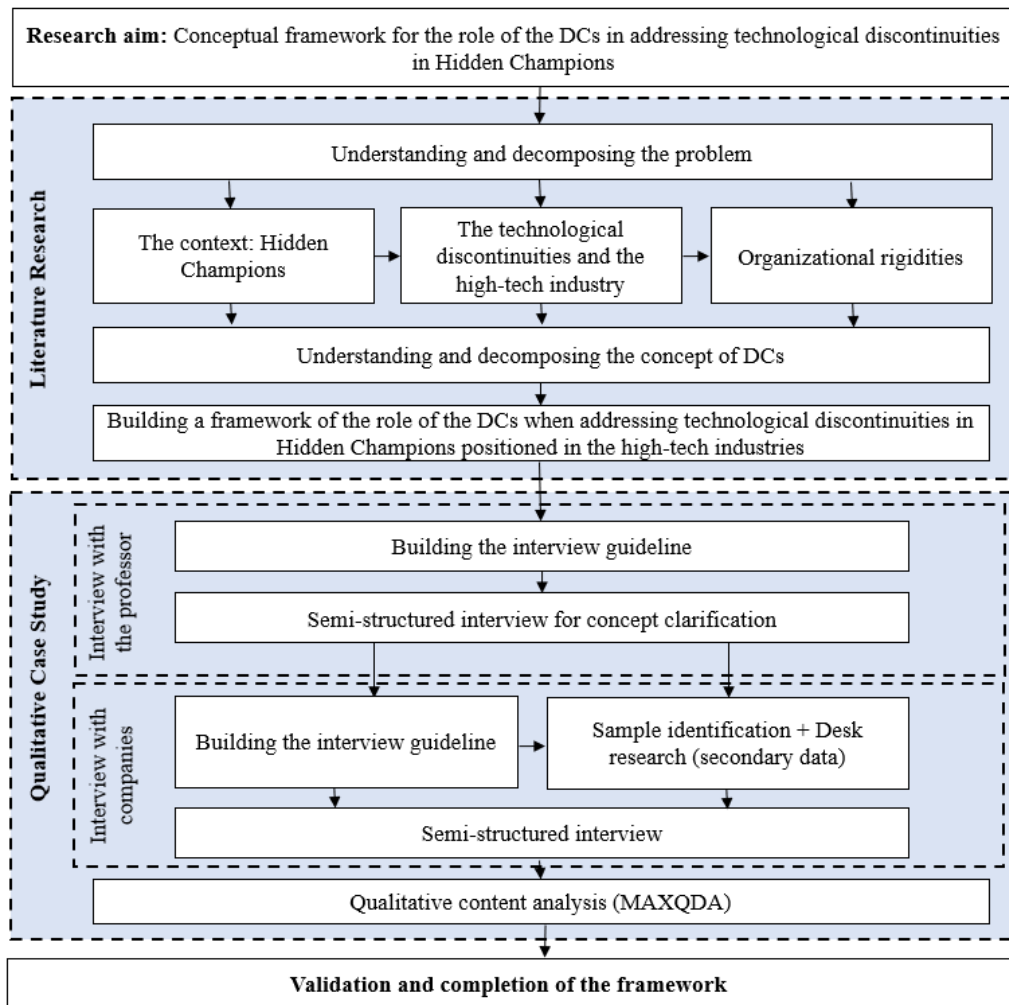
Despite the thorough previous research on both DCs (Teece, D.J., 2020) and HCs (Schenkenhofer, J., 2022), a research gap has been identified when considering both topics together. As such, the focus of this research is on the challenges created by technological discontinuities, focusing on the role of DCs when addressing these by the HCs positioned in high-tech industries. Even though each of the elements have been researched whether on their own or from other different perspectives, there is a lack of empirical research in this specific field. The research on the DCs in this specific context, however, is particularly relevant as it may provide important insights for those HCs when being challenged by the fast pace of the technological changes in their narrow niche markets.

To contribute to this lack of research, the context of the HCs, the technological discontinuities in high-tech industries, the organizational rigidities, and the concept of DCs have been analysed in detail. The different frameworks and studies that were done by Teece D.J. throughout his research career have also been thoroughly analysed. Based on the literature research and considering the different perspectives and number of interrelated elements that influence the DCs in a company, a new conceptual framework has been assembled to visualize the interrelation of the different variables influencing the HCs when addressing technological discontinuities (See Fig. 8).

To assess this framework and later validate its elements, qualitative research will be developed in this empirical study. Qualitative research, which can be defined as a multimethod in focus involving a naturalistic and interpretative approach to the subject of matter, attempts to interpret phenomena based on the meanings that the people bring to them. This involves the study of different empirical elements, such as personal experiences, case studies, and interviews which will describe the problematic elements and their meanings to the individual's reality (Denzin N.K., Lincoln Y.S., 2005). As such, it is based on assumptions and on the use of various theoretical frameworks to address the meaning that groups or individuals give to a specific problem (Creswell, J.W., Poth, C.N., 2018).

As the research aim is to first build and complete the DCs framework, and later test and validate this empirically, the qualitative case study approach is suitable in this case (Welch, C., Plakoyiannaki, E., Piekkari, R., et al., 2013). This qualitative research will be developed with deductive logic. In this respect, a framework has been first proposed based on the previous studies and the previous theoretical research. Later, this framework will be validated by the case study method which will enable the development of a comparative analysis of the data collection. The research design is developed as shown in the following figure (Fig. 9).





**Fig. 9.** The research design of the qualitative study.

As it can be seen in the previous figure, after building the conceptual framework based on the theoretical research, the qualitative case study was performed to gather empirical data and be able to complete and validate the model previously built. In this respect, and as also shown in the research design (see Fig. 9), semi-structured interviews were performed, first with a professor and later with the companies. This allowed making use of the insights gathered from the first interview with the professor in the later interviews with the companies. Also, additional information regarding the case firms was gathered from secondary data sources, such as the firm's websites, research papers, and company databases to complement the information obtained in the interviews.

During the semi-structured interviews (see interview guidelines in Appendices 1 and 2), open conversations were held in which the topic of matter, this is, the role of DCs when addressing technological discontinuities, was openly discussed. These interviews or conversations revealed the firms' practices and perspectives regarding the importance of DCs in this specific context. The interview guidelines were built as support for the conversation, in which the main concepts of matter, such as the technological discontinuities, organizational rigidities, DCs and the company's resources and strategies that bring them competitive advantage were included. This guideline was however slightly modified or adapted for each of the specific interviews depending on the direction of the conversations being held. Nevertheless, the main key elements were always covered.

### 3.2. Case Selection

To validate the proposed framework regarding the role of the DCs when addressing technological discontinuities in the HCs, a specific geographical region was selected for the research. In this regard, the research was focused on the high-tech companies inside the geographical region of Lithuania, a rapidly transitioned economy that reached the rest of the highly developed countries in a short period of time (Petraite, M., Dlugoborskyte, V., 2017). In that sense, it is important to consider that thanks to the economic policies being implemented in the country, a reliable economic environment has been created, which fosters and improves its attractiveness as an economic location for companies (Vaiginienė, E., et al., 2021). Lithuania is going through important economic changes, where it is moving towards a more innovation-driven economy (The World Bank, 2019). At the same time, the policymakers are also improving the business environment, which is now represented by high income, innovation-driven exports (World Economic Forum, 2015), and high economic freedom (Global rank 16th, The Heritage Foundation, 2017), which makes it more attractive for the development of the HCs (Vaiginienė, E., et al., 2021).

In this geographical region, the selection of the professor and the HCs positioned in the high-tech industries was done as follows. On the one hand, and regarding the professor, Prof. Habil. Dr. Arminas Ragauskas was chosen to have the first conversation, gather insights, and calibrate the focus of the research and the interview guideline for the later conversations with the HCs. Arminas Ragauskas is suitable for this research for his broad knowledge of the topic of technology management both from the academic and business perspective (KTU, Arminas Ragauskas).

On the other hand, the selection of the HCs was done based on Simon Herman's methodology (Simon, H., 2009). Therefore, companies that meet these four characteristics were selected: Small or medium-sized companies (SME), firms with annual revenue of less than €5 billion (or revenues that are at the level of SME), brands with low public awareness, and companies with top three position in the global market or number one in its larger region (Simon, H., 2009). Apart from that, and for the selection of the companies in this specific research, companies that operate in the B2B markets were selected, as it is also one of the main characteristics of the HCs.

To make the research in the specific context of the study, the high-tech industry positioned HCs were selected. The high technology is based on advanced scientific and technological expertise which requires more R&D expenditure (Keeble, D., Wilkinson, F., 2002). In the European Union, the high-tech products are divided into nine groups as reported by the International Trade Classification: aerospace, computer and office machinery, pharmacy, electronic-telecommunications, electrical machinery, scientific instruments, non-electrical machinery, chemistry, and armament (The World Bank, 2022). Therefore, the HCs that were selected for the case study were the ones that are part of the high-tech industries mentioned on the list.

### 3.3. Data Collection

Both primary and secondary data were used in this research, in which as indicated previously the data collection was divided into two main steps. First, an initial conversation was held with Prof. Habil. Dr. Arminas Ragauskas. This enabled to confirm that the proposed research problem or the focus of the research was correct, and it offered insights into the interrelationship of the concepts being analysed. This also enabled making modifications to the interview guideline for the companies. This interview was held in English and in person, and was recorded under the permission of the interviewee, who also agreed to his name being used during the research.

Second, and after the first checking with Prof. Ragauskas, the case studies in the HCs positioned in the high-tech industries were performed. To do that and set interviews with representatives in strategic positions in such companies and based on the predefined criteria presented in the case selection (see 3.2.), around 20 HCs were identified and contacted via email or LinkedIn to request an interview. In these requests, the topic of research and expected duration of the conversation were mentioned, together with the reason for the suitability of the company for this study.

From all the requests sent, in total 3 interviews with the representatives of 3 companies were conducted (see Table 4). These interviews were done with the General Manager, Chief Technology Officer, and Product Manager of the companies, always first making sure that these were in strategic positions and thus had an overview and general perspective of the firm. The interviewed firms are HCs positioned in high-tech industries, which include the manufacture of electrical equipment, the manufacturing of ultrasonic metering devices, and the software industry specialized in medical imaging and communication solutions.

During these interviews and before starting with the conversations, the anonymity and data protection of the companies and the representatives were first offered. Once this was confirmed, where all three participants accepted to publicly show the name of their companies, and after the recording of the interview was allowed, the topic of interest was explained once again, and the necessary concepts were clarified if needed. The interviews with the company representatives were conducted whether by video call or phone call due to the COVID-19 pandemic, busy schedules, and limited availability of the representatives. They were all conducted in English and their lengths varied between 30 minutes and 1 hour. The conversation with Arminas Ragauskas lasted 1 hour, and the conversations with the company representatives lasted 30, 40, and 45 minutes.

### 3.4. Data Analysis

After performing the interviews, these were transcribed by using the software *Trint* and then corrected or modified by hand. Altogether, 30 pages of transcriptions were collected to later be analysed using the software *MAXQDA 2022*, together with the secondary data gathered during the desk research. By making use of this software the qualitative content analysis of the case studies was performed (Udo, K., Stefan, R., 2019). During the content analysis, all the data gathered was processed by a coding system organized according to the elements included in the framework (see Fig. 8) and were later extracted. Those extracted text elements refer to relevant contributions to the research and the validation of the elements constituting the designed framework. These extracted text elements are provided below as quotes together with their respective codes.

## 4. Research Findings and Discussion

### 4.1. Overview of the Case Firms

After the classification of the selected companies as HCs (Table 3), a short description of the main areas of expertise of Prof. Habil. Dr. Arminas Ragauskas is shown below, together with further information about the case firms and the industries and markets in which they are positioned. In addition, an overview table of the firms is also included, showing their name, SIC-Code of the industry, the size, the founding date, the position of the representative being interviewed, and the duration of the interview (Table 4) As mentioned, all three companies allowed to publicly use their name in the research.

For the classification of the companies, the characteristics mentioned by Simon Hermann were considered (Simon, H., 2009). When doing this, the size of the company (which must be an SME), the annual sales revenue of the company (which must be less than €5 billion), and the market leadership are shown. As public awareness or visibility is quite difficult to measure, this condition was not regarded. Apart from that, broad boundaries were established for the market leadership, not only approaching the companies in the top three positions in the global market or number one in the larger region, but also approaching the companies successfully competing for these positions. Also, the three of them are B2B companies (Table 3).

**Table 3.** Overview of the HC classification.

Name	Size <sup>1</sup>	Annual Sales Revenue <sup>2</sup> (2020)	Market leadership definition
8Devices	Small	Approx. 3 million euros	European leader in the manufacture, development, and commercialization of embedded wireless modules (Vaiginienė, E., et al., 2021).
Axioma Metering	Medium	Approx. 20 million euros	One of the founders and leaders of ultrasound technology in the Baltic states, on its way to becoming the Top5 global player in the smart metering industry (Axioma Metering).
Softneta	Small	Approx. 1.7 million euros	Great success at the national and worldwide level by exporting the products to Continental Europe, North and South America, Australia, and Middle East Countries. (Kauno MTP).

<sup>1</sup>Size: The size categorisation has been done according to the EU definition of SMEs. European Commission (2020b).

<sup>2</sup>Annual Revenue Sales: Obtained from <https://rekvizitai.vz.lt/>.

### **Prof. Habil. Dr. Arminas Ragauskas**

The first indicative interview was conducted with Prof. Habil. Dr. Arminas Ragauskas, Professor, Habilitated Doctor of Science, Engineer, Member of the Senate of KTU (1989–2011) and Council, and Head of the Institute of Health Telematics (KTU, Arminas Ragauskas). During his career, he did not only establish the Telematics Science Laboratory at KTU in 1993, but he also co-founded the start-up company Vittamed in which he keeps the position as chief R&D officer. Thus, he is characterized for having extensive knowledge of the academic, scientific, and business perspectives of innovation and innovative technologies (European Patent Office, 2016).

During his career which spans over 50 years, he has written around 90 peer-reviewed scientific papers, and he has filed more than 90 patent families. Such is the value of his research, that he received the Lithuanian Inventor of the year award in 1981 and 1983, he was the finalist for the European Inventor Award in 2016 (European Patent Office, 2016), and he was awarded for Global Award for Science Innovations to Lithuania in 2019 (Global Lithuanian Awards).

### **8Devices UAB**

8Devices is a small SME that is positioned in the electrical equipment and component manufacturing industry. It is engaged in developing, manufacturing, and selling electronic equipment with unique design and functionality. With its expertise in hardware engineering and software design, they deliver high-quality products with the best performance and quick time to market approach. 8Devices also works with OEM (Original Equipment Manufacturer) and ODM (Original Design Manufacturer) wireless equipment projects, and they can also develop customized software and hardware solutions based on their specification list. Furthermore, since the year 2016, they are an official ADC (Authorized Design Center) of Qualcomm Atheros (Reikvizitai.lt Lithuania, 2022). The interview with 8Devices was conducted with the General Manager of the company (Table 4).

### **Axioma Metering UAB**

Axioma Metering is a medium SME which develops and manufactures ultrasonic heat, water metering, and data management devices. It provides accuracy and precision through the ultrasound technology, which was in fact, the first company in the Baltic States to implement this technology in a heat meter in 1992. By keeping pace with the latest technologies, they offer precision and quality, applying the new technologies to the water and heat metering devices and to the data collection systems that they also develop. Axioma Metering identifies itself as a team that is open to ideas, creative thinking, and innovation, striving to be the leader in Lithuania and in the world by offering products that are in line with the global trends (Axioma Metering). The interview with Axioma Metering was conducted with the Product Manager of the company (Table 4).

### **Softneta UAB**

Softneta is a small SME which is specialized in medical imaging and communication solutions. This company, which was founded in 2007, develops medical devices for the processing, visualization, and transmission of diagnostic medical data. Its unique products are designed to assist medical professionals in the daily decision-making processes by connecting all the medical data into a fast-performing and unified network. Furthermore, with their MedDream Universal Enterprise Viewer, they ensure an immediate and reliable way to search, view, analyse, and diagnose medical images, signals, and even video files on any kind of device (Softneta). The interview with Softneta was conducted with the Chief Technology Officer of the company (Table 4).

**Table 4.** Overview of the case firms.

Name, <i>Headquarters</i>	SIC – Code <sup>1</sup>	Size <sup>2</sup>	Founding Date	Position of the Representative	Duration
<b>8Devices UAB,</b> <i>Vilnius</i>	<b>3359</b> – Other Electrical Equipment and Component Manufacturing <b>335</b> – Electrical Equipment, Appliance, and Component Manufacturing	Small	2011	General Manager	40 minutes
<b>Axioma Metering UAB,</b> <i>Kaunas</i>	<b>3345</b> – Navigational, Measuring, Medical and Control Instruments Manufacturing <b>334</b> – Computer and Electronic Product Manufacturing	Medium	1992	Product Manager	30 minutes
<b>Softneta UAB,</b> <i>Kaunas</i>	<b>51821</b> – Data Processing, Hosting, and Related Services	Small	2007	Chief Technology Officer (CTO)	45 minutes

<sup>1</sup>SIC - Code: Standard Industrial Classification Codes.

<sup>2</sup>Size: The size categorisation has been done according to the EU definition of SMEs. European Commission (2020b).

## 4.2. Case Analysis of the Role of DCs in Addressing Technological Discontinuities

### 4.2.1. Arminas Ragauskas

Arminas Ragauskas has a long experience with the invention of new innovative technologies both from the academic and business perspective. That is why his point of view on the topic of technological discontinuities and how companies as HCs address these challenges is important. As such, when asking about technological discontinuities he referred to these as step functions from one technology to a better technology, which is defined as a paradigm shift. Nevertheless, during these technological discontinuities, he also referred to Schumpeter’s theory of creative destruction in which he indicated that when a technological discontinuity is happening, there is a time when both the old and the new technology coexist, “this is an example of the coexistence between the previous technology and the better technology” until the old one slowly dies “that means that nobody kills the previous technology. The technology slowly, perfectly, nicely dies.”

In this context of change and turbulence, he emphasized the necessity of the companies to adapt, referring to the theory of Darwinism from the business perspective „you will be killed by external forces, business forces, if you lose your ability of adaptation to change“. He emphasized the need for adaptability in the current dynamic markets, using the ranking of Fortune list of the biggest companies in the USA as a reference to the increasing dynamism of the market. Here the changes are becoming faster and thus, companies also need to adapt faster. This means that the internal dynamics of the companies also need to join the external dynamics „your internal dynamics must be compatible, you (the company) must react faster, you must reorganize your resources faster in order to be adaptive“, and he added, „this is always a challenge“.

When asking about the possible organizational rigidities when overcoming this challenge, he referred to the organizational rigidities as internal issues, and compared these with the rigidities in the brain

caused by growing tumours. As such, he emphasized that these are mostly caused by the management, „We have rigidity in the brain caused by the growing tumour. The rigidity of the company is internal, cultural. Is a psychological tumour of management“. Thus, he mentioned that management is in such a comfortable position that they lose the focus, creating a „terrible internal pathology“ in the company. Therefore, he highlighted that „if management is wrong you have consequences and different kinds of tumours (rigidities): longer reaction times, wrong decisions, wrong development vector...“. Additionally, he supported this idea with a specific example using as a reference the bankruptcy of Chrysler in the year 1980 in the USA, which as he mentioned was caused by „a terrible ineffectiveness and rigidity of the company,“ which needed to do a „surgery“ in the management positions to change that rigid system into a more flexible and adaptive one.

In this regard, and when referring to the companies' reaction to external changes and to how they overcome these, he emphasized that „everything depends on the philosophy, on the culture of the company, and the strategy“. In this context, he mentioned that the pragmatic businessperson always needs to make decisions to go in one way or the other, „the decisions, the trends, the shifts, and the development of paths depend on your philosophy, on your needs and goals. There will be a lot of points where you will have to decide to go this way or that way“.

When asking about the role of the DCs when addressing the technological discontinuities, and first referring to the ability to sense new opportunities, he emphasized the need for communication between the reality and the company, „you need to understand deeply all the needed details of the reality to decide how to react. Without sensing it is impossible to react“. The sensing methodologies need to be specific depending on the reality. When scanning the reality and identifying new opportunities, it is important to do a deep analysis, to identify the problem correctly and understand what the meaning is, which is always a question, „What will happen if you will be there, or there, or you do that, or that. You have to create a set of questions, very smart questions about your business: Goals, resources, competences of your people, your staff, etc.“ And for that, it is essential to make the right questions.

Thus, when it comes to sensing new opportunities, knowledge and practical experience are essential. This comes together with the tacit knowledge about the industry and the markets in which the companies are positioned. It is important to focus, „you cannot sense all the wide spectrum of events, you have to focus on your needs and the needs of your company“. Moreover, when sensing and identifying new opportunities, it is enriching to have a diverse experience, or a completely different education compared to the „regular path“, which means that „if you go out of the simple usual box, then you will be stronger, you will be smarter, lighter, deeper...“.

Nevertheless, and even if sensing new opportunities is a key step to later overcome the challenges, he emphasized that „sensing solves nothing, the decision-making and efforts solve problems“. Even if thinking and identifying the problem is important, it is essential to remember that „thinking gives nothing to reality. You can think and do nothing, and then, who solves the problem?“. Thus, addressing the opportunities is as important as sensing them. „You have to act. You have to make decisions“. When addressing these opportunities, he referred to the need of making efforts and mistakes. He demonstrated this with a theory of decision-making, which says that „if you are very close to the boundary or to that point where on the left side your business is still alive, but on the right side it is coming closer to death, in this point, you are very far away from the comfort zone. If you see that you are getting closer to the critical line, the recommendation is, do what you want, but do

something“. Therefore, it is important to think but it is also critical not to be paralyzed by thinking about the problem.

When it comes to the ability of the companies to transform and reconfigure, he again mentioned the ability to adapt to the changing environments. He emphasized main features in the companies that keep them more adaptive and able to transform, among which he mentioned the company size, the organizational structure, the communication, and the leadership. Regarding the size, „small nations, small companies, are faster than big ones“ because their internal process of information filtering is also faster. Regarding the organizational structure, he mentioned that the pyramid style organizational structure kills companies, as it creates rigid structures. Instead, „if you have a very flat, network-style company, in this case, you will have flexibility and adaptation“. Additionally, he emphasized the importance of creating an atmosphere with freedom of communication and a culture of real teamwork. And finally, he mentioned the importance of having special personalities, or leaders, „not artificially educated or created leaders“ but creative people who can do big things, and that can lead the companies even in rough periods. Here, he referred to the leadership of Vytautas Landsbergis, a musician, during the Singing Revolution in Lithuania, and the President of Ukraine Volodimir Zelenski, an actor, who is the leader nowadays in the conflict against Russia.

To sum up, Arminas Ragauskas believes in the importance of having harmony between the identification of opportunities and the ability to address these, „if you have good sensing but a bad mechanism or bad process of reaction to that sensing, this is disharmony“, and thus, the company will not be able to overcome the challenge.

Furthermore, when referring to the fast dynamics of the current markets he mentioned that these new opportunities and challenges are now becoming faster „there are changes everywhere and each of these changes is a new opportunity, a new possibility to do something better“. Specifically in the high-tech industries, the lifespan of the technologies is becoming shorter, which is also a source of stress and uncertainty for businesses. Thus, he mentioned that the only way to survive in these competitive environments is to open niche markets and be the leaders. Companies need to „propose something better“. If this idea is accepted by the customers and the users, then the niche market will start growing. However, keeping the leadership position is essential to survive, because as he said „after five minutes you have three, later five, and seven competitors, and after one month you have a hundred of competitors“. In these conditions of high competition, it is important to „fight“ using the legal ways by a strong patent portfolio, and if necessary, also by illegal means „forget ethics and fight like a crazy fighter for your survival.“ If something disruptive is getting closer to your business, „the reaction is to die, to fight, or to run away“. In these circumstances, having competitive qualifications and talented human resources is also crucial.

Finally, when covering the topic of the HCs, he emphasized characteristics by which these small or medium-sized companies become the leaders in their niche markets. One of the reasons he mentioned is that „they ask different questions, so they find different answers. Because of that, they are competing“. He highlighted that they are different to other non-hidden champions in the sense that they are smarter and deeper. Therefore, he highlighted the distinctive adaptation skills by which they show to be able to „do business in other countries and survive there, to do business even better than others... if we are talking about this kind of competition and adaptation, we have a nation as an example, which survived during 2000 years of travel“, referring to the Jewish Diaspora.



#### 4.2.2. 8Devices UAB

8Devices is an ADC and a producer of embedded wireless modules that are based on chipsets of Qualcomm Atheros. However, as the General Manager of the company also emphasized it, they are positioned in multiple markets. These markets include the wireless module business in which they also build power line modules, they have their manufacturing facility where they produce their prototypes and products for the customers, and they also work as an R&D centre for different companies. Thus, they have three main business areas, but their customer base is different, „our customer base is quite different, it can be from some simple household gadget, like a coffee machine, to even an airplane“. In fact, and as he also emphasized in another interview, one of the core lessons they have learnt is the necessity to diversify the activities as the clients can always cancel the order (Vaginienė, E., et al., 2021).

When asking about the technological discontinuities and their effect on the industry, he mentioned that „(these) definitely shape (the industry) because in the wireless connectivity market the technologies are always evolving and the new standards and the new chipsets come out every two years almost.“ Thus, he highlighted that it is important for companies to adapt to these changes and develop based on that. Nevertheless, sometimes these technologies are adapted slower to the market specifics as the customers tend to „stick to what works“. Thus, before starting to use the new technology they ask for all the necessary testing. However, in 8Devices they do not currently foresee any threat of new technologies in their specific niche markets, „when you have a specific niche and you already put your name on the customers, then it is not easy for them to transition, especially when you are in the market of components“. This means that if their customer is already using a technology and a specific product, then they are somehow locked in, and it is hard for them to change.

He emphasized that in times of change and adaptation to new technologies, the resistance and rigidity usually come together with the experience and age of the company, mentioning that „the more you fail, then the more you verify yourself before going into something new“. This way, previous failure while making decisions makes the companies implement rules, like handbooks, which are later followed when evaluating the risks in the market.

For 8Devices it is essential to consider the new technological opportunities, as „the market is changing and looking for ways to improve their products and stand out from the competitors as well“, also highlighting that „the difficulty is to get access to the latest technology“. To get access to that, in 8Devices they get direct support from Qualcomm, a partner from which they get annual trainings and product introductions, and where they are presented a roadmap on the coming trends in the next 12 months at least. By doing that, they can review the market requirements and their strategies toward these trends and build new products based on that. When getting this information, they also check with their „distributors and partners to know if this would be an interesting product for them“, and of course, also with their customers „as these are the ones who buy the product“.

Nevertheless, apart from these external information sources, they also have a team of senior engineers who „constantly follow and attend the seminars with those who develop the technology“, so besides the customer's feedback, their input will also be considered when building the product.

Therefore, when sensing new technological opportunities, 8Devices does thorough research and checks the different options in the market, where they evaluate the cost, the timing, and availability. Their partners' opinion also influences their decision. When making these decisions, the process

depends on the kind of technologies that are being analysed. If the new technologies are similar to the ones they use, it is easier, as he said „we have the expertise and we also have the customer base on which we can rely“, so the evaluation can be done fast. However, if the technology is unknown, they look for external expertise to help them with the evaluation. This requires a long process and a deeper analysis „before getting our hands in it.“ Besides that, 8Devices does not usually take that kind of step, as the ideas usually come from the internal team, who searches for the opportunities in the area in which they are working.

Once the new opportunities have been identified, he first emphasized, „well, sometimes we do not address at all, and we burn our fingers“. Nevertheless, he mentioned that during the decision-making process they make internal calculations of the needed financial investment and working hours, where they also get back to the customers to measure how much they would be able to sell. He emphasized that „there’s not a very solid structure or rules on how those ideas are managed“, it is a simple process and scheme where the ideas are evaluated, but „it’s not that we gather and vote and then decide“. As it is not a big company and the organizational structure is flat, it does not take long to make such decisions. Concerning new technologies, instead, it might be difficult to get some specific information, such as the market requirements. Then, they are forced to make assumptions based on their previous experience. However, if after the evaluation they decide to take the opportunity, „we can address very quickly because we have our resources to build the full product. So, if there is a demand we can start almost right away“. Therefore, their time to market is shorter.

Thus, when addressing a new opportunity in this industry it is important how well you can sell it, „how well you can package everything and how attractive you will be with the cost, and the other specifics of electronics like size, power, consumption, and so on“. From this aspect, he again emphasized the partnership with Qualcomm, „we tend to cooperate with a single technology developer, which is Qualcomm, because they are ahead of the competition in terms of latest developments, features, pricing, and everything“.

Concerning the ability to transform and reconfigure, he mentioned that in general they still follow the main path, and if there is demand in this market they will continue to do so. They are not changing the direction of the path, but they innovate on their technologies and products together with the technology suppliers. When keeping innovative and able to change, he emphasized the importance of being small and young. Being a small company helps them to be flexible and to adapt to the changing customer needs faster „you do not need to fill hundreds of pages for paperwork and get any approvals to make some small changes in the product“. So, in complicated situations their flexibility allows them to act faster and to adopt the changes easier. And he added, „since we are young and maybe sometimes a bit opportunistic, we usually take the risk“.

Finally, and when asking about what gives 8Devices a competitive advantage compared to the rivals, three main features were mentioned: the diversified customer base, its partnerships with other chipset vendors, and having their in-house production line. Having a diversified customer base allows them to lower the risks as „some of our customers will still be interested in what we make, and then we can adapt the solution based on our choices“. Nevertheless, the main competitive advantage of the company is the close relationship with Qualcomm and other chipset producers, which provide them with the latest hardware and software solutions. By using the newest technologies, 8Devices gets to position itself among the first in the market (Vaiginienė, E., et al., 2021). Not only that, by having its production line, the company gets to launch faster the new products as these are manufactured locally

and in-house. This production line is what offers a shorter time to market, as they have the resources to build the full product, „Basically from the idea to the product. We can make a design based on the idea, produce that, package it, and market it“. And he added, „having our own production line is like a time machine for us because if we would outsource the production the whole development process would take much longer“.

Lastly, and when referring to the key resources of the company, he emphasized the team and the people they have internally, „it is important to have a good team of developers who can construct a well-balanced and well-prepared product“. „The most important resource for us is people, as they are the ones that generate ideas, design the products, write the software...“. So, the company’s success does not only come from the customers but also from the „young and vigorous“ team (Vaiginienė, E., et al., 2021). And „then, of course, all the machinery and equipment, which help us to produce the products faster“.

#### **4.2.3. Axioma Metering UAB**

Axioma Metering offers measuring accuracy and precision by making use of the ultrasound technology, which they apply to the water and heat metering devices and the data collection systems they develop (Axioma Metering). As the Product Manager mentioned, it is a smart technology, but as he said, many companies are competing in the market “every company has different products, and they use different technologies.” However, globally speaking the market is crowded and occupied. Axioma Metering has been in this metering industry for thirty years now. In the beginning, they first introduced some big meters, which were meant for apartment blocks and industrial sites, and which measured big water volumes. But then, they changed to smaller meters and devices, “then we certainly understood that we can bring this technology to the apartment level so that we can scale the meters down to a very small size.” That is when they “made a game-changer in the market.” Then they started to make smart and modern meters which would be accurate, reliable, and affordable for every plant and apartment. However, he also mentioned that they are not alone in this niche market either.

Regarding the different technologies in the market, he mentioned the legacy technologies which were based on just mechanical parts, and the more recent and complex technologies which are based on different physical principles to measure the water flow. These last ones include the ultrasonic technologies they are using. He mentioned that “now we do not produce old mechanical meters anymore, we produce ultrasonic meters and that is our core competence.” However, he emphasized the fast pace of the industry of electronic components, in which they try to keep pace with the technology and “try to keep the same functionality for the customer.” Concerning discontinuities, he mentioned that sometimes “a good point is that even if our technologies are a bit different and we have different products, there are situations where we are all affected.” And he added, “that is actually good for us.”

When it comes to the organizational rigidities, he highlighted that among the two investment areas, the material and the non-material areas, they can still transform and reconfigure the non-material elements of the company, “like knowledge, R&D and the know-how.” However, “we cannot change the material part quickly.” The reason for this is that they have done a big investment to build a factory intensively for one type of technology, EUR 15 million were invested in the factory to manufacture

these state-of-the-art meters and which was opened in 2019 (Delfi, 2021). Thus, when asking about a possible technological discontinuity in the industry and their ability to change he mentioned that “this might be a very long way to go. We cannot switch, we cannot shift our technology very quickly because we have invested a lot and we have built our factory intensively for one type of technology.” This means that “we are flexible to some extent, but not by 100 per cent”.

Thus, when asking about their sensing capabilities he mentioned that they are constantly listening and following the trends and the new opportunities in the industry. When they identify a possible new trend or change, they first make a deep research and suitability studies. In these suitability studies, they ask questions such as “What are the chances that this will grow to something big? What are our chances and capabilities to implement it? How much money or time would it be needed? Do we own all the required resources to do that?” Once they check all these aspects, then they decide if they should start working on that or if they should keep it for later times. He emphasized that “we are listening, and we will listen to all potential game-changers and opportunities.” For the identification of possible new changes in the industry, they have the market intelligence team which is the one following the trends and making predictions. He also mentioned that Axioma Metering is a member of a few associations, where they “actively visit the fairs and participate in exhibitions.”

When sensing new opportunities, the voice of the customer is especially important. The product management and customer support department continuously get the customers’ feedback. There, they evaluate the different opportunities where they collect the customers’ demands and they transfer that information further to R&D and other teams. When they consider the customer’s demands, they use the system that they call the “wish list of the customer” where they write the suggestions. Then, once a week they have internal discussions with the bigger team where they evaluate each of the demands, “is it mandatory to change that for a correct functioning? Is it something additional that is nice to have? Can this change be left for future improvement?” These are also rated on a rational scale, “to measure how big is the business opportunity.” After all the evaluations and the analysis, then they decide if they go for that opportunity or if they leave it for later stages. Nevertheless, the suggestions that come from the customers are small improvements for their products, from which they receive good ideas. However, he also highlighted that, “the customers do not expect us to do some radical changes in our products, they know our possibilities and that we cannot make some drastic change.” “The customers know that we are bound to the current machinery and equipment.”

When they identify a good opportunity that they can address, they can do that easier in the not material parts. As their meters are produced in the assembly lines by robots and machines, they keep the same machinery, but they try to use alternative components. These still require additional investments in R&D. As he said, “we cannot change the hard part, but we can change the soft part, such as the software and the firmware.” However, these changes will require the team of R&D and programmers to write a new code for the new design. After that, “we will be using the same machines and the same assembly lines, but we will put a new heart in this new meter, and it will speak another language.” Nevertheless, he emphasized that it is not as easy as just buying a new part and mounting it in the old place. “We need to do some work, and this takes us a lot of time. It takes many months and large investments.”

Therefore, even if they have limitations regarding their machinery and assembly line, they are still flexible. They are aware of the fast pace of the industry of electronic components, and they try to keep improving their functionality through their customers’ feedbacks. As such, he emphasized that

it is important to be fast and reliable, and for that, he mentioned that “we need to proceed quickly, we need to be fast and to invest in our development if we want to keep growing.” In this aspect, they are ready to adapt their product and implement their customer’s needs, where they show to be more flexible compared to others. Based on that, they need to value their reputation in the market, as “it is easy to lose a customer, and very difficult to get them back,” which is the reason why it is important to keep the promises. Nevertheless, and when referring to possible big changes he assured that “we cannot stop now, shut down everything for six months, and switch on again. The challenge is to survive this transitional period also because we need to pay salaries and we need to deliver the products to the customers.”

Finally, and when asking about what gives them a competitive advantage compared to their rivals, he mentioned the closeness to the customers, “our customers say: you have very big ears, and you listen to our demands.” In Axioma Metering, they focus on not just selling the product but on solving the customer’s problems, where they try to reach long term partnerships. This close customer relationship, the willingness to solve their problems and to answer to their demands by investing time and effort from their side, is also what helps them adapt easier their product. Lastly, and when referring to the key resources of the company, he emphasized the know-how and the knowledge of their developers. The professionals are the most valuable in the company. However, he also added that „we have a quite nice and modern factory, and we also have a lot of stable financing“, which are also important resources in Axioma Metering.

#### **4.2.4. Softneta UAB**

Softneta is a company that was founded in 2007 and which has more than fourteen years of experience in the development of medical imaging and communication solutions. They try to improve the quality of healthcare by offering medical devices for the processing, visualization, and transmission of diagnostic medical data (Softneta). When asking about the market in which the company is positioned, the CTO mentioned that inside the medical imaging market, which is a noticeably big market that is growing exponentially, they target the specific niche market dedicated to the visualization. Adding that “this means that we provide medical viewers, and in such case, this market is quite small, around 1 hundred million US dollars”. In this specific niche market in Europe, around 10 companies are competing, and he added that “we are one of the leaders and we feel the competition mainly from other two companies, one from the USA and another open-source product that is developed by a community”. This last one is free but has no certifications “which are important in the healthcare industry.”

When asking about the technological discontinuities in the industry, he mentioned that these have a big impact, and he added that they have already participated in two of these technological changes. Thus, he added that “we already had two technological migrations during our company’s life.” In this industry, the technology changes every 8 years, where they have already done two and they are now preparing for a new migration, a term used in information technology (IT) to refer to the process in which the data processing or information systems are converted to different technology. These migrations, however, require large financial investments and a big effort. Nevertheless, he assured that “it is good that technologies change, as they add new features and offer a better performance.” Still, the migration time is “painful” not just for the company but also for the customers, and this is also where resistance comes from “from their (the customers’) perspective, something that before

was working it is not good anymore, at least for some time until the change is completed, and the migration is finalized.” After that, and once it is done, “everyone is happy as the new technologies always offer a better quality and performance.”

However, this also depends on the type of change. Sometimes these are drastic technological shifts that force the companies to migrate and make the changes because otherwise, they will get out of the market. Other times this is not crucial, and the new technologies do not bring special benefits. Then it is fine not to migrate. This depends on the improvements you are forced to make, and thus, it is important to “always check the competitors and what they are doing.”

Among the different organizational rigidities, the resistance to change and the lack of financing are important obstacles when being challenged by new technologies. This resistance to change can be seen both in the employees and in the customers as “this usually means a big challenge for both.” Regarding the customers, when new technologies are being implemented, they are afraid that these might have malfunctions in the beginning. And he added, “and honestly, this is usually true.” The migrations usually have issues at first, where some features need to be fixed more frequently than with the old technology. However, he still emphasized that “this is a good signal as it means that work is being done on improving the technology.” This in the end adds new features and offers better performance.

In Softneta they identify new opportunities or approaching trends in different ways. These include their customers or partners, as these are the ones who identify first the needs in the market, and the competitors, where he mentioned that “it is important to check always what they are doing.” Apart from that, the main input to migrate from one technology to another usually comes from the media and from how big players react to these technologies. Companies such as Google, Amazon, Microsoft, and Apple have a big impact on the IT industry. “If there is a technology that a big player is refusing to use, this means that this technology will die and that you should migrate to a new one.”

Before addressing any new technology, they do thorough research where they investigate “what technologies are coming and how these will impact our products and our customers.” There, they will decide if it is the moment to change or not. They also do prototypes to make sure that it brings benefits. However, this always depends on the type of change, in times of drastic technological shift it is mandatory to do the change if they want to keep in the market.

When they decide to migrate and start the process to address the new technology, they focus on their customers, as in the medical industry it is important to do the testing and prototyping in the real environment. They first offer the new product or options to some users, for which they enable the new features and technologies, and where they do the trials and get the feedback. If the new technology is working properly, they enable it for the rest of the customers, otherwise, they make the necessary improvements. He added that from their 35 employees, “8 people are dedicated just to create or to make this migration, whether making some improvements in the technology or making some drastic changes in the functionality.”

The company needs around 3-4 years to do a drastic change, which also requires 20-30% of the company’s investments, as despite the changes they need to assure the same or better performance and functionality for the customers. For instance, they are now preparing for a new migration which will be ready in 2 years. However, they are aware that “after 6 years probably the market will be

discontinued again by a new technology. Then, we will need to migrate our solution also and change. This means a large investment.”

As Softneta is a small company, the main source of financing has been the European Grants, which they have used for the research and technology migration, and to compensate the salaries of the employees. Apart from that, sometimes also the partners compensate and help them in the investments for the migrations, usually when the technological change is important or even mandatory for them. When doing these migrations, “being small helps to be flexible.” In that aspect, he added that “if you get stuck with an old technology and you do not change to the new one, then the company will be out of the market.” For a big company, it is more difficult to adapt fast. Nevertheless, he also emphasized that even if Softneta is a small company, they already have around 300 customers that are using their products, which is also challenging, “if you change something in the product you need to keep all the customers satisfied, as the solutions we offer are highly customized and they have different configurations”. This means that making improvements is also challenging, as all 300 customers want to have the same functionality and performance.

In this regard, he mentioned that in this industry, transforming is not an option “you are forced to do so if you want to survive.” However, it is not an easy process as these changes may also bring problems with the customers “some want to keep using the old technology, as they have the old computers and servers”, in these situations he added, “we have two options, or we also keep supporting the old technology, which requires additional costs, or we skip to the new one, which means that we can lose some customers”.

Among the things that bring competitive advantage to the company, he added that “it fits to the specific needs that all customers are expecting,” meaning that they support different types of integration including different operation systems, devices, and databases. This is essential in the healthcare industry, as the products need to be compatible with other companies’ solutions. In Softneta, “as we have a flexible visualization tool, we can be integrated into different solutions and provide diverse features.” However, the key aspect that brought a competitive advantage to the company was the new vision: “Our vision is to be a trusted technology partner and provide universal access to medical imaging and intelligence.” With this change, they understood that the advantage does not come from selling the products to hospitals or distributors, but from partnering with other companies that also develop medical products. There he added that “we listen to and partner with our customer, and this is a unique business model.” Thus, “the flexibility of the company itself and the flexibility of the product is what gives us a competitive advantage.”

Finally, and when asking about the key resources, he mentioned the competence of the people. It is not enough with having people with IT skills, “it is even more important to have people who understand and are working in the field of medical imaging.” In that respect, they have 3 to 5 employees in the team who have been working there for 15 years, so “they know the market and they know the product very well”. Thus, the key advantage is the people and the motivation to improve. And of course, the financing, “because even if you have good people and a lot of experience, without financing it will be very difficult to survive.”

#### 4.2.5. Summary of All Cases

In conclusion, and even if the three HCs are positioned in different high-tech industries, first, they are all aware of the challenge of technological discontinuities and the necessity to react to them. Apart from that, looking across the case firms, they all make use of the sensing, seizing, and transforming or reconfiguring DCs, which they apply when addressing possible technological discontinuities or new opportunities in the market. However, there are both similarities and discrepancies in how the companies pursue these activities, which are influenced by the size of the company and the specific industry and niche market in which they are positioned. This can be seen for example in the extent of flexibility or ability to transform and address new opportunities. The different elements mentioned in the case firms regarding the proposed framework (Fig. 8) are compared in the following section to validate the model.

#### 4.3. Comparative Analysis of the Case Firms When Addressing Technological Discontinuities

A comparative analysis of the three HCs has been conducted in which the main elements of the proposed conceptual framework (Fig. 8) have been analysed showing the similarities and the discrepancies between the firms. For the elements of the conceptual framework which are marked as codes, each of the sub-categories is also shown, together with the meaningful quotes obtained in the interviews. These are all summarised in tables.

#### Perspective Regarding Technological Discontinuities and Organizational Rigidities

The technological discontinuities and organizational rigidities are two of the key elements presented in the framework as these constitute the problem being analysed. Therefore, it is essential to understand the perspective of the case firms regarding the technological discontinuities in their industries and possible organizational rigidities. In the following table (Table 5), the quotes that refer to the technological discontinuities and the organizational rigidities are shown.

All three companies, 8Devices, Axioma Metering and Softneta, mentioned that the technological discontinuities happen at a fast pace and that they have a big impact on their high-tech industries (sub-categories *the pace of technological change* and *impact of technological discontinuities*). Related to that, both 8Devices and Softneta mentioned the necessity to adapt to these changing environments (sub-category *need to adapt*). Nevertheless, when it comes to the rigidities, a broad number of resistances have been found, which were not always related to the firm. First, all three companies regarded the possible resistance to change coming from the customers (sub-category *resistance from customers*). Second, apart from the customers, there are also other sources of resistance, among which can be mentioned the age of the company, inability to change the material assets of the company, and lack of financing, for example (sub-category *other sources of rigidity*).



**Table 5.** Extractions for the technological discontinuities and organizational rigidities for the framework.

Category	Sub-Category	Quotes
Technological discontinuities	The pace of technological change	“The new standards and the new chipsets come out every two years almost.” (8Devices)
		“The industry of electronic components is developing very quickly. If we think of a smartphone 3 years ago it was very much different from what we have today.” (Axioma Metering)
		“If we think about the technological discontinuities or changes, every 8 years technology changes.” (Softneta)
	Impact of technological discontinuities	“They definitely shape (the industry) because in the wireless connectivity market the technologies are always evolving.” (8Devices)
		“Even if our technologies are a bit different and if we have different products, sometimes there are situations where we all are affected. All competitors are affected.” (Axioma Metering)
		“The technological discontinuities have a very big impact... and we have already participated in two of these huge technology changes.” (Softneta)
Organizational rigidities	Need to adapt	“You really need to adapt and develop based on that (the technologies are always evolving).” (8Devices)
		“Then, we will need to migrate our solution also, and change to the new technologies.” (Softneta)
		“It also depends on the type of change, sometimes is a drastic technological shift. Then it is mandatory to make the changes otherwise you will get out of the market.” (Softneta)
	Resistance from customers	“Once a customer is locked in the specific product it is much harder to change.” (8Devices)
		“Customers tend to stick to what works. So first they want to try, see, and test, and then develop the product based on that.” (8Devices)
		“Customers don't expect us that we will do some radical changes to our products.” (Axioma Metering)
		“We already have around 300 customers or companies that are using our product, and this is also challenging. If you change something in the product.” (Softneta)
		“This is why customers are resisting to some changes, from their perspective, something that before was good it is not good anymore, at least for some time.” (Softneta)
	Other sources of rigidity	“Resistance usually, I think, comes with the experience and the age of the company. The more you fail, the more you verify yourself.” (8Devices)
		“But we cannot change the material part quickly.” (Axioma metering)
		“The resistance to change, and also one of the biggest resistances is also the lack of money, or lack of resources, lack of financing...” (Softneta)
		“And not only the employees but also the customers.” (Softneta)

### Manifestation of Dynamic Capabilities When Reacting to Technological Discontinuities

As the aim of the research is to understand what the role of the DCs is when addressing the technological discontinuities in the HCs, the companies were also asked about their sensing, seizing, and transforming capabilities. In the following sub-chapters, the perspectives, and the practices of the three HCs are shown, always in the context of technological discontinuities in their specific high-tech industries and markets. In this regard, and to offer a more structured analysis, the elements that refer to OI have been included here.

## Sensing Dynamic Capability

As all three companies seem to be aware of the fast pace of the technology in their respective industries, they all have their methods by which they identify new opportunities and trends in technology (Table 6). All three HCs have an internal team, department, or internal process by which they identify and follow the trends in the market (sub-category *internal team*). However, they do not limit their research to the internal team, but they all give importance to their customer's opinion, which is considered when measuring the possible demand, when making improvements, and when making important decisions (sub-category *customer's opinion*). Furthermore, they also emphasize in Softneta that they consider their customers as partners and that by doing this they are closer to the needs of the market. Nevertheless, and even if they do not name them specifically as partners, also 8Devices and Axioma Metering keep a close relationship with their customers, as these are meaningful information sources in both cases.

Despite the internal teams and the customers, all three companies also make use of external sources or partners to identify new trends in their industries and markets. As such, 8Devices makes use of the close partnership with Qualcomm which gives the company direct support, Axioma Metering gets information not only from their suppliers, but also actively participates in fairs and exhibitions, and finally, Softneta keeps a close eye on media and on what bigger players are doing in the industry, as this has a big influence on the future development of the technology in the IT industry (sub-category *use of external sources*).

**Table 6.** Extractions for the sensing DC for the framework.

Category	Sub-Category	Quotes
Sensing capability	Internal team	"We have a team of senior engineers who constantly follows the trends." (8Devices)
		"Either demand is coming from our internal team who sees the opportunity." (8Devices)
		"We have the market intelligence team that follows the trends." (Axioma Metering)
		"The source of information is our product management and customer support department." (Axioma Metering)
		"We do some works to investigate what technologies are coming and how these will impact our products and our customers." (Softneta)
	Customer's opinion	"(Customer's opinion) is important because these are the ones who buy." (8Devices)
		"Or the demand for something new is coming from our customers." (8 Devices)
		"We are in between, we collect the videos that give us our customers and we listen." (Axioma Metering)
		"(The customers) they rather ask for some small changes and improvements and they give us a lot of good ideas." (Axioma Metering)
		"We catch all our customers' demands. We have a system we call the "wish list of our customers." (Axioma Metering)
		"Customers also help us identify new opportunities. We treat customers as partners, as they are the ones who usually see the need in the market." (Softneta)
		"The trends in the customer" "This is important. If you see these trends, then you can also see what technologies are better to be used and how to improve your solution." (Softneta)
		"We listen to our customers." (Softneta)
	Use of external sources	"We get the direct support from Qualcomm, and they do annual trainings, product introductions, they present a roadmap." (8Devices)
		"Check with our distributors and partners if this would be an interesting product for them." (8Devices)
		"Constantly follow and attend the seminars with those who develop the technology." (8Devices)
"We know in advance we have agreements with our suppliers, and they notify in advanced." (Axioma Metering)		

		“Axioma is a member of a few associations. We also actively visit the fairs, and we participate in exhibitions.” (Axioma Metering)
		“It is important to always check the competitors: what they are doing.” (Softneta)
		“The main input to migrate from one technology to another usually comes from media and from how big players are using it.” (Softneta)

### Seizing Dynamic Capability

After identifying the possible new trends and technologies in the industries, the three HCs show a diverse way in which they follow the decision-making processes and address these opportunities (Table 7). 8Devices emphasized that because of their small size and flat organization, their decision-making process does not have a solid structure or specific rules about how these ideas are managed, and it has a simpler way to evaluate the opportunities. Instead, in Axioma Metering they make their thorough investigations and suitability studies (sub-category *characteristics of the decision-making process*).

However, when it comes to the process of decision-making, even if all three mention a process in which in the end they take a decision, the steps of the process vary from one HC to the other. In the case of 8Devices, they analyse the amount of investment needed, the customer demand, the timing of the commercialization of the product, and the suitability of the product. They do this while frequently checking with their customers and partners. In Axioma Metering, they do suitability studies where they answer similar questions as 8Devices regarding the investments needed, the impact of the new technology, and the effort and resources needed for addressing the new opportunity. At the same time, and based on their specific task list, they make decisions about starting, stopping, or continuing with specific projects. In Softneta, before directly addressing the new technologies, they also first make some prototyping and analyse the benefits and suitability keeping a close relationship with the customer. After that, and once they make sure about its benefits, they decide to implement the technology further or not (sub-category *decision-making process*).

When it comes to addressing the new technologies or opportunities, the three companies also vary in their response. In 8Devices they emphasize that they are fast and flexible when addressing new opportunities, where they are even able to start right away thanks to their in-house production. In Axioma Metering instead, they assure that they need to do some work before directly addressing a new opportunity, which requires thorough research and time. They also added that they are not in the position to make those changes so easily. In Softneta instead, once they decide that they should address the new opportunity, they start with the technology migration, which takes around 3 to 4 years to be completed. During this process, they keep a close relationship with their customers, as they need to ensure at least the same functionality and performance as with the old technology (sub-category *addressing the opportunity*).

**Table 7.** Extractions for the seizing DC for the framework.

Category	Sub-Category	Quotes
Seizing capability	Characteristics of the decision-making process	“There's no very solid structure or rules on how those ideas are managed. Of course, in the end, we do all the final estimations and consultations.” (8Devices)
		“We are not a big company, so our organization structure is quite flat, and it doesn't take long to make such decisions.” (8Devices)
		“It's quite a simple scheme where you can evaluate.” (8Devices)
		“If we hear something that is likely to become a new trend, we will investigate, we will make some suitability study.” (Axioma Metering)
	Decision-making process	“This is an internal process where we look into how much we need to invest from our side to make the product happen... and then we talk with the customers to know how much we can sell.” (8Devices)
		“We check what are the possible options in the market, evaluate the cost, the timing, and the impact in terms of availability. Check with our main partners if they are interested in this solution.” (8Devices)
		We have a task list for our R&D... we look at this task list and we say: we stop doing this, we stop doing that, and we focus on that.” (Axioma Metering)
		“We make some suitability study: What are the chances that this will grow to something big? What are our chances to implement it? How much money and time do we need? What resources? And then we decide if we start working on that now or later.” (Axioma Metering)
		“We do some prototyping for checking and see if it brings benefits.”, “After seeing if it is useful or not, then we make the decision to implement it further or not.” (Softneta)
		“We can address very quickly because we have our own resources to build the full product. We can start almost right away.” (8Devices)
	Addressing the opportunity	“We are much faster. The time to market is shorter.” (8Devices)
		“Since we are young and sometimes a bit opportunistic, we usually take the risk.” (8Devices)
		“We cannot just start buying a new part and mount it in the old place. We need to do some work, and this takes us a lot of time.” (Axioma Metering)
		“For example, if you do a drastic change, this takes around 3-4 years.” (Softneta)
		“When we do the trials, we enable these features in our products. We first offer these options for some users... After some time and the trials, if the new technology is working, we enable it for the customers and if not, we make the improvements.” (Softneta)

### Transforming Dynamic Capability

In the fast-paced technological environments in which the three HCs are positioned, they all mention the importance of being able to adapt and to transform quickly, where they all mention that they need to evolve together with the technology (sub-category *importance of transforming*) (Table 8). However, when doing this, some discrepancies can be found in the ability and the extent to which the companies can reconfigure themselves. In this regard, 8Devices showed to be fast and flexible when addressing new opportunities where they mention to have space to add some internal projects also. Nevertheless, even if in Axioma Metering they mention their flexibility and ability to address their customers' needs, they still mention that they are not flexible to 100 per cent. Thus, they can make some improvements and small works but not radical changes. Apart from that, in Softneta they mentioned that reconfiguring is sometimes not an option, and they are forced to do so if they want to keep competing in the market. Furthermore, during the 15 years of their company's life, they have already participated in two “transformations”, and they are now preparing for the third one (sub-category *ability to transform*).

Finally, there are some aspects such as having a diverse customer base, and the flexibility that being a small company offers that enable an easier transformation of the companies (sub-category *enablers of the transformation*). However, some obstacles hinder the easy transformation of the companies, some of the aspects mentioned here are the previous investments made on machinery in the case of

Axioma Metering, and the customer’s resistance or inability to change in the case of Softneta (sub-category *obstacles to the transformation*).

**Table 8.** Extractions for the transforming DC for the framework.

Category	Sub-Category	Quotes
Transforming capability	Importance of transforming	“To survive in the high-speed growing electronics market, you need to “run with the rapidly developing” very quickly.” (8Devices, Vaiginienė, E., et al., 2021).
		“Because the industry of electronic components is developing very quickly.” (Axioma Metering)
		“Important is being fast and being reliable.” (Axioma Metering)
		“If we think about the technological discontinuities, every 8 years technology changes.” (Softneta)
		“Changing is not a choice, you are forced to do so. If you do not change you cannot survive.” (Softneta)
		“Now there are new technologies that are coming ... We need to prepare our technology for these changes too.” (Softneta)
		“Being adaptive to change is critical.” (Softneta)
	Ability to transform	“8devices launched 1 embedded wireless module in 2011 and now has 15. Every electronics manufacturer every year has to show a new product that differentiates it from its competitors.” (8Devices, Vaiginienė, E., et al., 2021).
		„We usually have a space to add some internal project as well“. (8Devices)
		“This might be a very long way to go. “, “We are "flexible" to some extent, but not by 100 percent.“ (Axioma Metering)
		“We can rather go for some small works and small improvements, but we are not in a position to make a radical change and to start again.” (Axioma Metering)
		“Customers don't expect us that we will do some radical changes to our products, they know our possibilities and that we could not make some drastic change.“ (Axioma Metering)
		„We already had 2 technological migrations during our company’s life“ (Softneta)
	Enablers of the transformation	“We have diversified the customer base, for us it’s easier to be flexible now.” (8Devices)
		“Flexibility because you can adapt to the market, to changing customer needs.” (8Devices)
		(Being a smaller company)” You do not need to fill hundreds of pages of paperwork and get any approvals to do even small changes.” (8Devices)
		“When transforming and reconfiguring, being small helps to be flexible.“ (Softneta)
	Obstacles to the transformation	“We cannot shift our technology very quickly because we have built our factory intensively for one type and we invested a lot.” (Axioma Metering)
		“We cannot stop now, shut down everything for six months and then switch on again. The challenge is to survive this transitional period also.” (Axioma Metering)
		“These migrations also impact the customers, because some usually stay in the old technology because they have old computers, old servers...” (Softneta)

## Resources and Strategy Providing Competitive Advantage

Finally, the firm’s resources and strategy that bring competitive advantage compared to the rivals are also key elements to consider from the systems’ perspective (Table 9). Even if they all somehow refer to certain tangible resources as their machinery or equipment and financing (sub-category *tangible resources*), the three companies emphasized their employees and the team, referring to their competences and knowledge (sub-category *intangible resources*). Apart from the company’s resources, they also mentioned different aspects that bring 8Devices, Axioma Metering, and Softneta a competitive advantage compared to their rivals, among which can be mentioned the company’s characteristics (sub-category *company’s characteristics*), the external sources (sub-category *partners*), the characteristics of the products (sub-category *characteristics of the product*) and the customers, which seem to be one of the key success factors in all three companies (sub-category *customers*).

**Table 9.** Extractions for the resources and strategy for the framework.

Category	Sub-Category	Quotes
Resources	Tangible resources	“All the machinery and equipment, which help us to produce faster.” (8Devices)
		“We have a quite nice and modern factory, and we also have a lot of stable financing.” (Axioma Metering)
		“And of course, also the financing... Because even if you have good people, even if you have a lot of experience, without financing it is very difficult.” (Softneta)
	Intangible resources	“The key to the company’s success is not only the clients but also the “young and vigorous” team.” (8Devices, Vaiginienė, E., et al., 2021)
		“The most important resource for us is people because they generate the ideas, they design the products.” (8Devices)
		“Our key resource is our know-how, our knowledge, and our developers. The professionals are the most valuable at Axioma.” (Axioma Metering)
		“One of the key resources is the competence of the people.” (Softneta)
“Also, people who understand and are working in the field of medical imaging ... they know the market, they know very well the product...” (Softneta)		
Strategy (Source of Competitive Advantage)	Company’s characteristics	“High quality, competitive price, and the company’s flexibility to work with niche vertical markets.” (8Devices, Vaiginienė, E., et al., 2021)
		“The quick launching of the new products as they are manufactured locally and in-house.” (8Devices, Vaiginienė, E., et al., 2021).
		“The flexibility of the company itself and flexibility of the product.” (Softneta)
	Partners	“The close relationships with Qualcomm and other producers... allows the company to be among the first in the market.” (8Devices, Vaiginienė, E., et al., 2021)
		“Partnering with some of the chipset vendors, we are able to get the latest hardware and software solutions from them.” (8Devices)
		“The vision of considering the customers as partners.” (Softneta)
	Characteristics of the product	“We are ready to adapt our product, we are ready to implement what the customer needs. We are a bit more flexible compared to others.” (Axioma Metering)
		“It fits to the specific needs that all customers are expecting... we support many integration types.” (Softneta)
		“Thus, the flexibility of the company itself and flexibility of the product gives competitive advantage.” (Softneta)
	Customers	“The “right clients” are crucial success factors, as they are the distributors who are aware of customer needs and know the market.” (8Devices, Vaiginienė, E., et al., 2021)
		“We are closer to the customers. Our customers say, “you have very big ears, you listen to our demands.” (Axioma Metering)
		“We reach for long term partnerships. We do not want to make one-time deals, but once we establish a partnership we want to stay for many years.” (Axioma Metering)
		“That we are technology partners to our customer. We listen to our customers.” (Softneta)

#### 4.4. Validation of the Framework of the Role of Dynamic Capabilities in Addressing Technological Discontinuities

For the validation of the proposed framework, each of the interviewees offered a different perspective. Arminas Ragauskas presented a broader and more academic viewpoint, while each of the HCs provided insights from their specific context and industries: 8Devices from the electrical equipment and component manufacturing industry, Axioma Metering from the water metering industry, and Softneta from the medical imaging industry. Adding Arminas Ragauskas to the research brought meaningful insights, which complement those features mentioned by the case firms from a different point of view. There are discrepancies between the proposed framework based on the theoretical study (Fig. 8) and the validated framework developed after the empirical research (Fig. 10). This emphasizes the importance of developing empirical research based on case studies, as it enables to bring the theoretical aspects to the real environment.

Regarding the concept of technological discontinuities, which was defined as the challenge that the HCs need to address and thus the main reason for research in this work, all HCs and Arminas Ragauskas are aware of the impact of these discontinuities on the companies. Moreover, and even if the pace of the technology varies from one industry to the other, they all agree that the technologies in the high-tech industries have a short lifespan which forces them to adapt faster to these external changes. Nevertheless, when it comes to the concept of organizational rigidities, there were discrepancies in the responses. Arminas Ragauskas mentioned several organizational rigidities mostly originating in the management of the companies and which are a source of ineffectiveness. These rigidities hinder the companies to react to external changes. During the case studies in the three HCs, other types of aspects were mentioned, such as the company size, the age, and the previous failures or bad experiences. However, one of the most mentioned sources of resistance were the customers, where all agreed that, these are against radical changes in these B2B markets. Therefore, the element of the organizational rigidities has been kept in the framework but has been rephrased as “rigidities and resistance”, and its representation has been changed from symbolizing an obstacle, to being shown as a reinforcement to stay in the old technology (Fig. 10).

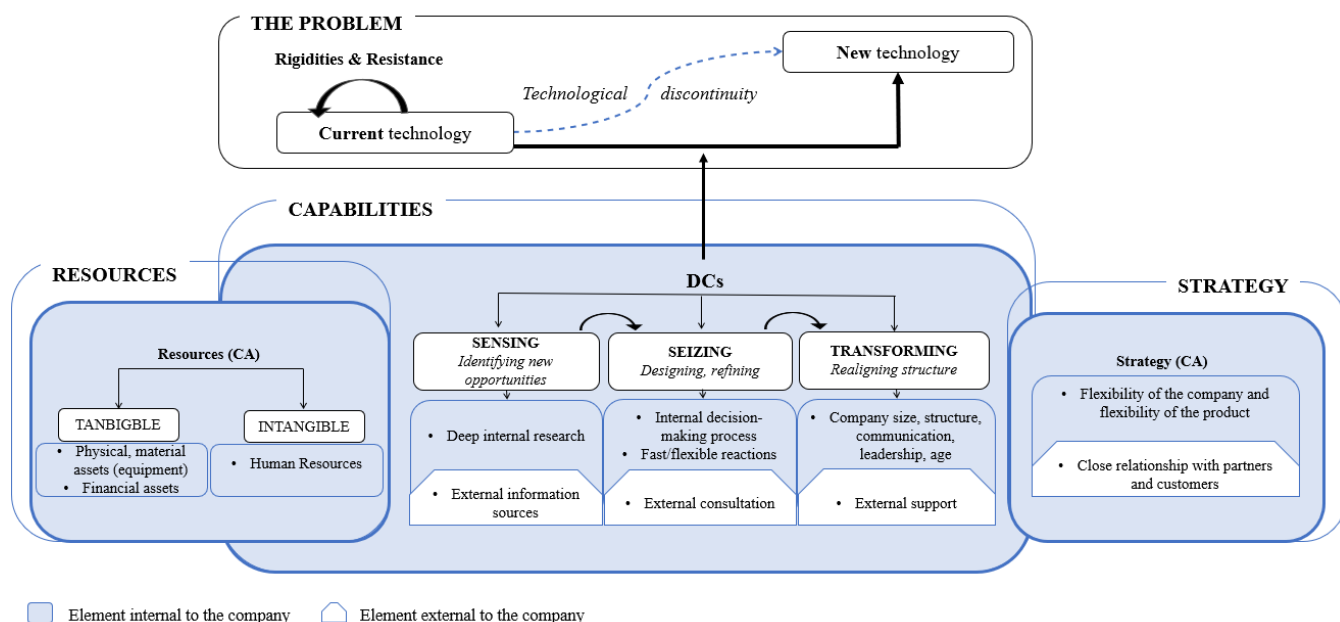
During the research and the case study, it has been proved that the DCs have an important role when addressing technological discontinuities in the high-tech industries in which the HCs are positioned. When addressing technological discontinuities, not only Arminas Ragauskas but also the three HCs emphasized the importance of adaptation, where they all showed to have sensing, seizing, and transforming capabilities, which enable them to react to possible external challenges, such as the introduction of a new technology in the market. Regarding the sensing capabilities, doing constant and thorough research of the technologies and changes being developed in the industries is essential. Thus, having internal professionals, a team or a department that is responsible to identify new trends is important. Nevertheless, and apart from the internal team, having good communication with external sources of information such as partners, customers, distributors, suppliers, and other associations is also a way to keep track of the development of trends in the high-tech industries.

When it comes to addressing the identified opportunities, and as is also highlighted by Arminas Ragauskas when he mentioned that the actions and the decision-making are what solve the problems, the three firms mentioned that they all have a decision-making protocol. The specifications vary from one company to the other, but they focus on the suitability, the necessary investments of time and effort, benefits, and disadvantages of approaching the opportunity. Moreover, they all refer to the importance of including the opinion and the feedback of external sources, which include partners (8Devices) and specifically customers (Axioma Metering and Softneta).

Nevertheless, an important feature mentioned by the representatives was that this process varies depending on their knowledge regarding the new technologies being addressed. Thus, both 8Devices and Axioma Metering, mentioned that they are flexible and fast when addressing technologies inside their areas of knowledge or expertise. However, when the new technology is more “distant” from their area of knowledge and thus requires a more radical change, they are more reluctant, and they require more external consultation in the case of 8Devices. Instead, in Axioma Metering they emphasized that they are not able to address this kind of radical changes, as they are bound to the current technology by their machinery and equipment. When it comes to Softneta, because of the fast pace and high influence of the technologies in the IT industry, the drastic changes are usually the ones that they are forced to do, as not changing means getting directly out of the market.

Apart from that, the three HCs emphasized the importance of adaptability and transformation in the fast-moving environments in which they are positioned. When talking about the ability to transform, they all emphasized the advantages of being small and flexible, where 8Devices also added the convenience of being young and risk averse. When it comes to Axioma Metering, despite being a bigger company that is bound to its current machinery, they still affirm to be fast and flexible inside the boundaries of their technology, which is important to keep their customer's reliability. Softneta instead, in its 15 years has proven to be able to transform and "migrate" its technology successfully twice. From their perspective, being small is also a key factor to be flexible. When transforming, they also again mentioned the support from external sources.

Regarding the last two elements, the resources and the strategy or practices that bring competitive advantage to the company, both Arminas Ragauskas and the three HCs emphasized that their key resource is the team. Therefore, having the right team of professionals and competent people with diverse backgrounds (as said by Arminas Ragauskas) and with the market knowledge and the necessary skills, is essential in the companies, in addition to the stable financing and the quality of equipment and machinery. When it comes to the practices or characteristics that bring competitive advantage to the company, the flexibility of both the company and their products seems to be an advantage when competing against the rivals in the niche markets. Nevertheless, and despite the internal flexibility, having external support from partners and customers is an important source of advantage too. This enables them to have a broader perspective and a constant track of the changes and developments being done in their market and industry. As it is shown in the framework, these external participants accompany the firms all along the process and journey. Considering all the previously mentioned, the revised and validated conceptual framework for the role of the DCs when addressing technological discontinuities in the HCs is shown below (Fig. 10).



**Fig. 10.** The validated conceptual framework of the role of DCs in addressing technological discontinuities in HCs.



In this research, the aim was to build a framework to visualize the role of the DCs in the HCs positioned in high-tech industries when addressing technological discontinuities. During the research process, a first theoretical framework was proposed based on the previous research done about the HCs and DCs (Fig. 8). However, after the empirical qualitative case study developed in the HCs in high-tech industries, a validated framework has been proposed above (Fig. 10). As it is noticeable, the proposed framework before and after developing the case study has some discrepancies. As such, the framework has been limited to those concepts that were mentioned to be important in the interviews, and thus, elements such as complementors, institutions, and specifically VRIN resources have been deducted from the model. Therefore, the model has been constrained to the features covered and confirmed by the HCs and by Arminas Ragauskas.

Furthermore, during the case studies, it has been confirmed that technological discontinuities are a major concern in these specific companies, where the DCs play an important role when overcoming this challenge. Also, the practices of the HCs for the sensing, seizing, and transforming capabilities have been validated and verified, demonstrating the process that is followed in the companies when reacting to these challenges. Furthermore, the additional characteristics as the resources and the strategy that bring competitive advantage to the company have also been discussed and added to the framework, as these enable to have a clearer perception of the specific context and characteristics of the HCs.

## **4.5. Discussion**

### **4.5.1. General Patterns Identified in the Hidden Champions**

During the case study and the validation of the framework, some main patterns have been identified among the HCs which also coincide with the perspective of professor Arminas Ragauskas. It has been confirmed that the HCs positioned in high-tech industries are conscious of the impact the technological changes and discontinuities have in their industries and the challenge they represent for the companies. It is not only unanimous that technological discontinuities are challenges that the companies need to react to, but it is also a shared assumption that it is essential to be adaptive to change and flexible to be able to react to these external changes.

When addressing possible technological discontinuities or new technological trends, the DCs and therefore, the sensing, seizing, and transforming capabilities play a key role in the HCs. When doing this, they own internal and external sources of information to follow the new trends being introduced in the industry, or to identify possible game-changers in the markets. In this respect, the constant track of possible new opportunities in the market and the industry is a shared practice. Once the new opportunities have been identified, a decision-making protocol is started. This process varies from one HC to the other, but different evaluations are done to analyse its suitability and the resources and financing needed, which is also performed together with the consultation of external participants, customers, partners, or suppliers. During this process, having fast reactions is also relevant. To keep the ability to transform and avoid path dependencies in the companies, important characteristics are size, structure, age, and the type of leadership. Apart from having an agile organization, having external support is also a key element. As it has been validated, the integration of external sources and the practice of OI is ubiquitous in every step of the process.

When addressing new technologies or opportunities, two main trends have been distinguished among the HCs depending on the proximity of the new technologies or trends to their knowledge base or expertise. In that sense, they are faster, more reactive, and responsive to the changes and trends that are happening inside their knowledge base and established technologies. Nevertheless, the ability to react to technological discontinuities happening outside their knowledge base seems to be lower, where they have longer and more thorough evaluation protocols, with additional external consultations. Additionally, they are also more restricted regarding the extent to which they can address these new technologies, where they are constrained by the machinery and equipment, or the customer base.

When gaining a competitive advantage over the rivals, having a competent team of skilled professionals is the most valuable resource in the HCs. Apart from that, being flexible themselves and offering flexible products is relevant, where the close relationships with the customers and partners provide them with an advantage compared to their competitors in the markets.

#### **4.5.2. Discrepancies Between the Theoretical and the Validated Framework**

During the research, some modifications have been done from the conceptual framework that was developed by disassembling and assembling again the frameworks proposed by David Teece in his previous research, to the validated and completed framework developed after the case study.

The problem identified in this work was the challenge of HCs to address technological discontinuities in the high-tech industries in which they are positioned. When reacting to technological discontinuities, organizational rigidities, whether structural or capability rigidities (Dąbrowska, J., Lopez-Vega, H. et al. 2019) could be a consequence of threats in the environment or resource abundance (Soltwisch, B. W., 2015), were identified as obstacles. Therefore, in the first theoretical framework, these organizational rigidities were presented as obstacles for the change, while the DCs were shown as tools to overcome them. Nevertheless, after the empirical case study, and even if the concept of rigidities and resistance to change was frequently mentioned and referred to by the HCs, these were regarded as forces that incite the companies to stay in the old technologies, rather than obstacles that DCs help to overcome. Among the rigidities and resistances mentioned, the rigidities caused by inefficient management and hierarchical structure, the size and age of the companies, and the resistance to change coming from the customers, partners, or employees could be mentioned. However, and even if these rigidities are shown to be reinforcing the use of the current technologies, or hindering change to the new ones, these have never been regarded as obstacles that DCs enable to overcome. Thus, and even if these two elements have proven to be important in this context, the interrelationship proposed in the theoretical framework was not confirmed.

When asking about the key resources that bring competitive advantage to the companies, the reference to the VRIN resources was quite scarce (Barney J.B., 1991), where they all emphasized the valuableness of the resources. Thus, mostly the companies' intangible assets were mentioned, highlighting the value of the team. Apart from that, other tangible resources were also mentioned, which include the equipment, machinery, and financial resources that enable these companies to compete in these high-tech industries. However, and even if the value of the resources was underlined, the rest of the aspects as being rare, imperfectly imitable, and non-substitutable were not specifically

referred to by the HCs, even if the importance of having a strong patent portfolio was highly emphasized by Arminas Ragauskas.

In addition, integration of external participants and thus, the practice of OI is so ubiquitous in the HCs, that the external elements have been directly incorporated as additional elements of the process, instead of as minor extensions. This enables to confirm the importance of OI for technology management when gaining a competitive advantage over the rivals (Teece, D.J. 2020). As a last remark, and as no main reference to complementors was done during this specific study, this element has been removed from the validated framework. However, this might still be an important aspect to consider in other HCs.

### **4.5.3. Theoretical and Managerial Implications**

#### **Theoretical Implications**

Regarding the theoretical implications of the main concepts covered in this research, aspects such as technological discontinuities in high-tech industries, organizational rigidities, and DCs could be mentioned in the context of HCs.

Regarding the technological discontinuities in high-tech industries, it has been confirmed by the research that these are important challenges for the HCs, which are highly aware of the necessity to react and adapt to the external changes happening in their environment. In these fast-moving environments, organizational rigidities or resistances to change have been identified to work as reinforcements to stay in the old technologies. However, and as mentioned previously, it has not been confirmed that the DCs serve as tools to specifically overcome these obstacles. Therefore, further research would be required to better understand this interrelationship. Nevertheless, when it comes to the DCs, the case study suggests that these practices are widely implemented in the firms when reacting to technological discontinuities, even if the HCs do not refer to them specifically. Thus, the sensing, seizing, and transforming capabilities have been seen to be important when addressing technological discontinuities, showing that the theory of the DCs is suitable for explaining and understanding the phenomenon of how HCs address technological discontinuities and other turbulences in their fast-moving environments. This adds to the previous research done about the DCs. Finally, and when it comes to the HCs, a new perspective on the topic has been approached, which opens the field for further research regarding the DCs and their role when addressing technological discontinuities in their narrow niche markets.

#### **Managerial Implications**

Besides the theoretical implications, this research also offers managerial implications for HCs positioned in high-tech industries facing the challenges of the fast pace of the technology cycles. In that respect, and even if they all have important sensing, seizing, and transforming capabilities, they do not seem to be aware of the concept of DCs itself. Therefore, it might be insightful for the companies to internally analyse the level or extent of their sensing, seizing, and transforming capabilities, to have the whole perspective of the process and identify capability gaps in conditions of change.

Apart from that, in this kind of research, it is an important remark to consider diverse perspectives on the topic, as has been done by including professor Arminas Ragauskas. This additional point of view enables to overcome biases of only considering representatives of strategic positions in the companies, and it provides a more critical perspective regarding the actual management of the companies. Thus, when it comes to further managerial implications, it must be interesting to consider the opinion of researchers on the topic.

#### **4.5.4. Limitations and Prospects for Future Research**

Being a Master Thesis based on theoretical research and focused on the interviews with a professor and three HCs, the findings of this qualitative research do not allow to make a broad generalization of all HCs positioned in high-tech industries. Even though all three companies are HCs, they are all diverse from each other regarding their size and the industries in which they are positioned, even though they are all high-tech industries. Despite insightful results that have been obtained during the study, a prospect for future research would be the further study in the same context, this is in the high-tech industry positioned HCs, by more extensive research considering a larger sample. This would enable to find clearer patterns in the practices of the companies based on the industry or the company size. It would also enable to get more in-depth insights regarding the role of the DCs when addressing technological discontinuities in HCs and their general practices or trends.

Therefore, one of the main limitations of this study is the number of case companies. The sample of three HCs for the qualitative study cannot reflect the HCs positioned in the high-tech industries. Therefore, and even if interesting and insightful information has been gathered, this study just opens this new field of research. Besides that, a single interview was conducted with each of the firms, which means that even if these were substantial conversations that were also supplemented with secondary data, there are still more insights and information from the companies that could be gathered to have the whole picture of the firms.

Nevertheless, the qualitative research of the case studies provides a first exploration of the role of the DCs when addressing technological discontinuities in HCs. Thus, this first exploratory research opens future research prospects that include broader qualitative research, in a larger and more significant sample, to gather more insights and validate and complement further the proposed framework. In this bigger sample, it should be ensured that the companies being studied are distributed homogeneously depending on their size and industry or markets in which they are positioned, as this might also bias the obtained results. Once this is performed with a larger sample and once the saturation point is confirmed (Saunders, B., Sim, J., et al. 2018), further quantitative studies could be performed for a deeper understanding of the relationship between the elements of the framework which would help to corroborate the findings of this research (Kelle, U., 2006)

To sum up, for future research, a more in-depth study with a larger and diversified sample of HCs positioned in high-tech industries would offer more insights, by performing several interviews to complement the data and to make sure that the whole picture of the company is being considered. This further research would offer a broader picture of the role of the DCs in addressing technological discontinuities in HCs positioned in the high-tech industries.

## Conclusions

- 1. The technological discontinuities have a big impact on the HCs positioned in high-tech industries, where it is essential to be able to identify and adapt to these external changes.**

The technological discontinuities are a source of uncertainty for incumbent companies, especially in the high-tech industries due to the fast pace of the technological development. These technological discontinuities, which happen as periodical paradigm shifts, have disruptive effects on both the firms and the overall structure of the given industry. These turbulences force the firms to adjust and adapt to the external changes if they want to keep their positions in the market. When it comes to the HCs positioned in these high-tech industries, and narrow niche markets, these technological discontinuities have a significant impact on them, as the companies' performance and the position in the market are conditioned by the technologies they own. Thus, technological turbulences have a higher importance in such fast-evolving environments as they force the companies to identify and react to these changes even faster.

- 2. The DCs, which consist of the sensing, seizing, and transforming capabilities, enable the companies to address technological discontinuities, whereas organizational rigidities interfere in the process.**

When addressing technological discontinuities in environments of rapid technological change and high uncertainty, the DCs enable the integration and reconfiguration of the external and internal competences. By the sensing, seizing, and transforming capabilities, the firms gain a competitive advantage by renewing the owning competences to adapt to the changing environment. To do this, it is required to appropriately adapt, integrate, and reconfigure not only the internal but also the external skills.

When addressing new technological opportunities, there might be different organizational rigidities or resistances to change which interfere in the process and hinder the companies from addressing these new opportunities. Among the different organizational rigidities, the structural or capability rigidities are of importance, which can be caused by different reasons, such as path dependencies caused by continuous success where the change of trajectory becomes significantly more difficult to take place. Nevertheless, apart from the rigidities intrinsic to the company's characteristics, among which can be mentioned the ineffective management, rigid company structures and leadership, or even previous investment decisions, these are sometimes also combined by resistance to change. This resistance can come either from the inside of the company, such as the employees or managers, or from external participants, such as customers or partners. These rigidities and resistance to change reinforce the company to stay in the old technologies and not address the new technological opportunities.

- 3. The conceptual framework developed from the theoretical research for the role of the DCs when addressing technological discontinuities in HCs consists of elements such as the sensing, seizing, and transforming capabilities, together with other interrelated elements as resources and strategy, which bring competitive advantage over the competition. In this framework, other external sources and thus OI plays an important role when addressing these challenges. Organizational rigidities, however, hinder the companies from reacting to these technological discontinuities.**

Based on the previous research on the topic of DCs by David Teece, and after disassembling and reassembling the frameworks proposed in this research, a conceptual framework has been constructed for the specific context of the HCs when addressing technological discontinuities. Thus, the main elements of the proposed framework are the capabilities, the resources, and the strategy that provide a competitive advantage to the companies when addressing new technological opportunities. Inside the capabilities, the sensing, seizing, and transforming capabilities are shown as key elements when addressing these new challenges. Inside the resources, the VRIN resources, and thus the valuable, rare, imperfectly imitable, and non-substitutable resources are added, which are considered to provide a competitive advantage compared to the competition.

In addition, external participants have been also included, such as the possible complementors, institutions, partners, universities, customers, or research institutes that can serve as an external knowledge source. The use of external knowledge, and thus OI is shown to be an influencing factor of the DCs when addressing technological discontinuities. In the framework, the organizational rigidities hinder the change from the old technology to the new technology and thus are shown as obstacles, while the DCs enable the companies to react and therefore overcome this challenge.

- 4. The qualitative case study methodology of the thesis is based on the integration of scientific literature on HCs, technological discontinuities, and publications on DCs from different perspectives, and is rooted in the elements of the developed conceptual framework. This enables to understand the role of the DCs when addressing technological discontinuities by developing the case studies in HCs positioned in high-tech industries, and consulting the perspective of a professor, through semi-structured interviews and subsequent content analysis.**

After the bibliographic research and the development of the conceptual framework, a qualitative case study has been performed to assess the role of the DCs in addressing technological discontinuities in high-tech industry positioned HCs. For the validation of the framework and before the case study development, a first interview was performed with the professor Arminas Ragauskas, who has extensive knowledge of the academic, scientific, and business perspectives of innovation and innovative technologies. This first indicative conversation enabled to approach the topic from a broader perspective and to ensure that the direction of the research was suitable for the context. Subsequently, the qualitative case study was performed in three Lithuanian HCs positioned in high-tech industries where semi-structured interviews were conducted, and secondary data was collected by desk research. The interview guideline was built based on the elements of the proposed conceptual framework. During the conversations, the elements of the framework were discussed, and the practices and perspectives of the companies were commented on, which enabled the validation and completion of the proposed framework by comparative content analysis. The content analysis was done by making use of the *MAXQDA 2022* Software.

- 5. Based on the empirical research of the conceptual framework elements with the professor and the case study firms, it can be stated that the DCs have an important role when addressing technological discontinuities in HCs. Here, other factors such as the key resources and the strategy, offer the firm a competitive advantage compared to the rivals. However, some modifications have been done to the framework after its validation. First, the organizational rigidities are not depicted as obstacles to the change, but as resistance**

**forces or rigidities that reinforce the companies to stay in the old technology. Second, elements such as complementors and VRIN resources have been removed for their low significance during the research. Third, the concept of OI has been integrated into the framework for its significant presence during the process.**

The qualitative case study enabled to confirm the important role of the DCs in high-tech HCs when addressing technological discontinuities. Therefore, it has been proven that they all make use of the sensing, seizing, and transforming capabilities to be able to adapt to their fast-changing environments, even if they do not mention the concept of DCs specifically. It has been emphasized that the incumbent companies are highly aware of the fast pace of the technology cycles in high-tech industries, where companies are forced to adapt to changes if they want to keep positions in the market. They furthermore agreed on the rigidities and resistance to change to have a negative effect when reacting to these changes. Nevertheless, concerning different sources of resistance or rigidities in the companies, among which can be considered the company size, the age of the company, the current machinery or equipment, and resistance to change coming from the customers or employees, these are mentioned as reinforcements to stay utilizing the old technology and avoid addressing new opportunities. However, these have not been proven to be obstacles that the DCs help to overcome when reacting to technological discontinuities.

Furthermore, regarding the DCs, HCs have shown to react to possible technological discontinuities or changes in the market by sensing and seizing new opportunities, while they also keep their ability to transform to be able to respond to possible future challenges. Along the process, the HCs have shown to have a high integration of the external sources, mostly customers, partners, and suppliers, providing HCs with support and advice. This close relationship with external participants has been also mentioned by the HCs as a source of competitive advantage compared to their competition. Therefore, these OI practices have been integrated directly into the framework instead of showing them as minor extensions.

When it comes to the resources that bring competitive advantage, among the VRIN characteristics, the valuableness of the resources was emphasized, paying special attention to the intangible resources, and especially to the team of competent and skilled professionals as the most valuable resource in the HCs. The technical level of both the company and the employee's knowledge is a key aspect to keep a competitive advantage and a good position in the high-tech industries.

As for the strategy to differentiate from their competition, having a flexible and adaptive company, and offering flexible products is a key advantage, apart from the mentioned close relationships with the customers, partners, or suppliers. Apart from that, and as there has not been a direct reference to the complementors during this specific study, this element has been removed from the validated framework. However, this might still be an important aspect to consider in other HCs.

## **6. Two different patterns of reaction to the technological opportunities have been identified based on the proximity of the technologies to the knowledge or expertise of the HCs.**

HCs perform continuous and thorough research both internally and externally to identify possible new opportunities. While maximizing the company flexibility and adaptability to be able to address new opportunities and transform when required, their ability to address new opportunities depends on the proximity of the new technologies to the expertise of the company. Thus, when these new

technologies are inside the knowledge base of the HCs, they have fast reactions which are allowed by the flexibility of both the product and the company itself. Nevertheless, when the new opportunities are outside the knowledge base and expertise of the company, they have longer response times with additional external consultations, and more limitations when transforming and addressing the new opportunities. When it comes to the more distant technological opportunities, they are more reluctant to change, which is justified by the limitations of their current equipment or machinery and customer base.



## **Recommendations**

Technological discontinuities are a source of high uncertainty for their disruptive effects on the structures of the industries, where they force the incumbent companies to adjust and adapt to the changes to keep their positions on the markets. The companies positioned in the high-tech industries, and HCs in specific, seem to be aware of this challenge and the need to keep adapting and responding to the changes in their environments. Thus, general practices of sensing, seizing, and transforming capabilities can be observed in the HCs, which enable them to be aware of the new opportunities and trends in their industries and react to threats.

Nevertheless, despite the already established processes to address these challenges, the HCs do not directly refer to the concept of DCs. Therefore, it might be beneficial for the managers and decision-makers to have an overview of the general practices of the DCs in the companies. This will enable them to identify the strengths but also the weaknesses or capability gaps when sensing and seizing new opportunities and when keeping the ability to transform. By having a closer look at each of the DCs, the HCs might be able to identify a broader spectrum of opportunities and address challenges more successfully in the fast-moving environments in which they are positioned. This will also allow the identification of existing gaps, limitations, or restrictions that the companies may have. This might be convenient when drafting the future perspectives and planning the long-term goals.

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## Appendices

### Appendix 1. Interview guideline for Arminas Ragauskas

Section	Questions
<b>Permission for recording and for using the name in the research.</b>	
<b>Introduction</b>	<ol style="list-style-type: none"> <li>1. Would you agree that with your invention you created a technological discontinuity in your industry?</li> <li>2. How do these discontinuities manifest in the industry?</li> <li>3. Did this new technology affect the rest of the incumbent firms positioned in the industry?</li> <li>4. Was the industry ready for this new technology? Was there any resistance or rigidity?</li> </ol>
<b>Getting into the concepts</b>	<b>About technological discontinuities</b>
	<ol style="list-style-type: none"> <li>1. To which extent do technological discontinuities shape an industry?</li> <li>2. To which extent should these be considered for the future development of solutions in the companies?</li> <li>3. What are the reactions from the incumbent firms?</li> <li>4. When a new disruptor comes to the industry where a Hidden Champion is, how do these react? What is the behaviour when they identify other technological solutions?</li> <li>5. Are there specific skills/qualities/capabilities that define the firm's ability to react to these discontinuities?</li> </ol>
	<b>About organizational rigidities</b>
	<ol style="list-style-type: none"> <li>1. When the technological discontinuities are being developed, how do the companies cope with these? Are there any rigidities?</li> <li>2. What kind of resistance can be seen in the incumbent firms?</li> <li>3. Which are the main challenges companies need to overcome when reacting to technological discontinuities?</li> <li>4. What kind of capabilities support these actions and enable companies to react to the discontinuities?</li> </ol>
	<b>About DCs</b>
	<ol style="list-style-type: none"> <li>1. When being challenged by technological discontinuities in an industry, which are the most important capabilities in a company? And how is this done?               <ol style="list-style-type: none"> <li>a. The ability to sense new opportunities</li> <li>b. The ability to seize new opportunities.</li> <li>c. The ability to transform and reconfigure.</li> </ol> </li> <li>2. How important are the DCs in this context?</li> <li>3. How do the sensing, seizing, and transforming capabilities interrelate?</li> <li>4. How do firms orchestrate all these DCs?</li> </ol>
<b>About HCs</b>	<ol style="list-style-type: none"> <li>1. Which are the skills/features that allow HCs to react to the technological discontinuities faster/ more appropriately?</li> <li>2. Which are the most important capabilities in HCs in this context? And how is this done?               <ol style="list-style-type: none"> <li>a. The ability to sense new opportunities</li> <li>b. The ability to seize new opportunities.</li> <li>c. The ability to transform and reconfigure.</li> </ol> </li> <li>3. In which aspects do you think this is different from managing DCs in another kind of company?</li> </ol>
<b>Ending</b>	<p>Is there anything you would like to add, or any recommendations you would like to make?</p> <p>Thanks for the interview.</p>



## Appendix 2. Interview guideline for the companies

Section	Questions
<b>Permission for recording and for using the name in the research.</b>	
<b>Introduction</b>	<ol style="list-style-type: none"> <li>1. First, could you give a short explanation of your specific niche market and the current competitive situation there?               <ol style="list-style-type: none"> <li>a. How crowded is the market?</li> <li>b. Which technologies are being used?</li> </ol> </li> </ol>
<b>Getting into the concepts</b>	<b>About technological discontinuities</b>
	<ol style="list-style-type: none"> <li>1. To which extent do technological discontinuities shape an industry?</li> <li>2. To which extent should these be considered for the future development of solutions in the companies?</li> <li>3. What are the reactions from the incumbent firms?</li> <li>4. Are there specific skills/qualities/capabilities that define the firm's ability to react to these discontinuities?</li> </ol>
	<b>About organizational rigidities</b>
	<ol style="list-style-type: none"> <li>1. When a company is already positioned in a niche market in the high-tech industry, and new technologies are being developed, how do companies cope with these changes?</li> <li>2. Are there any rigidities? What kind of resistance can be seen in the incumbent firms?</li> <li>3. Which are the main challenges companies need to overcome when reacting to technological discontinuities?</li> <li>4. What kind of capabilities support these actions and enable companies to react to the discontinuities?</li> </ol>
<b>Getting into the concepts</b>	<b>About DCs</b>
	<ol style="list-style-type: none"> <li>1. When being challenged by technological discontinuities in your industry, what is the role of the following DCs in your company?               <ol style="list-style-type: none"> <li>a. The ability to sense new opportunities. How do you identify or sense new technological opportunities? How important is this when addressing technological discontinuities?</li> <li>b. The ability to seize new opportunities. How do you address new opportunities? How important is this when addressing technological discontinuities?</li> <li>c. The ability to transform and reconfigure. How do you keep your ability to transform? How important is this when addressing technological discontinuities?</li> </ol> </li> <li>2. How important are the DCs in this context?</li> <li>3. In which aspect is this different from managing DCs in other larger companies?</li> </ol>
	<b>About the resources and the strategy</b>
<b>Ending</b>	<ol style="list-style-type: none"> <li>1. Which resources would you say are sources of competitive advantage in your company?</li> <li>2. Regarding the specific niche market strategy that is being pursued, where does your company show an advantage regarding the competitors or rivals?</li> </ol>
	<p>Is there anything you would like to add, or any recommendations you would like to make? Thanks for the interview.</p>