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What is the contribution of Open Innovation on Net Zero?

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Abstract

Open innovation is a worldwide spread method to innovate products, processes, based on a change of approach in terms of sources of innovation, shifted from the traditional R&D approach to a new paradigm centered on the external influence of different actors. Net Zero is the political response to the climate change issue, that posed the attention on the emissions derived from a fossil-fuel-based world economy. It is the political will to make Europe and the world net-zero-emission by 2050. These two themes are nowadays widespread among big companies' strategies, and the intersection between them is a comprehensive view of how open innovation could be the methodological pattern to solve climate change problem. Literature about open innovation and the positive effects on companies' innovation paths is broad and rich, but a systematic analysis of the contribution of this innovative OI paradigm on Net Zero is missing. A very big gap can be found in the analysis of how OI contributes to Net Zero and what are the specific skills and capabilities needed to tackle these projects. The aim of this thesis is to connect OI and Net Zero, providing a comprehensive view about the contribution of OI regarding Net Zero, and the capabilities and skills needed by companies to undertake very specific projects that transform business to achieve 2050 net-zero targets. To fulfil the aim of this research, I conducted semi-structured interviews to 20 CIOs (Chief Innovation Officer) from Italian companies in different sectors. Findings suggested how OI applied to generic projects is a widely discussed topic which finds confirm in literature, but some relevant gaps about the contribution of OI on Net Zero, and skills and capabilities needed to undertake these projects are filled with contribution from interviews. This thesis provides some relevant contribution to literature: a collection of some very specific

positive and negative aspects of OI in the field of Net Zero, addressing benefits, limitations, network value and internal organizational awareness, and an analysis of the skills and capabilities needed by companies to undertake Net Zero projects with the help of external partners.

Key-words: Open Innovation, Net Zero, competences, skills

Abstract in italiano

L'open innovation è una metodologia diffusa in tutto il mondo, nata per promuovere l'innovazione di prodotti, processi, incentrata sull'influenza esterna di diversi attori, e diversa dal tradizionale approccio interno di R&D. Il Net Zero è la risposta politica alla questione del cambiamento climatico, che ha posto l'attenzione sulle emissioni derivanti da un'economia mondiale basata sui combustibili fossili. È la volontà politica di rendere l'Europa ed il mondo a zero emissioni nette entro il 2050. La letteratura sull'OI e gli effetti positivi sui percorsi di innovazione delle aziende è ampia e ricca, ma manca un'analisi sistematica del contributo di questa sul Net Zero. Un divario molto grande può essere trovato nell'analisi di come OI contribuisce al Net Zero e quali sono le competenze e le capacità specifiche necessarie per affrontare questo tipo di progetti, che mirano a decarbonizzare i business. Lo scopo di questa tesi è collegare i due temi, fornendo una visione completa del contributo dell'OI al Net Zero e le capacità e le competenze necessarie alle aziende per intraprendere progetti molto specifici che possano trasformare il business al fine di raggiungere gli obiettivi Net Zero del 2050. Per raggiungere l'obiettivo di questa ricerca, ho condotto interviste semi-strutturate con 20 CIOs (Chef Innovation Officer) di aziende italiane in diversi settori. I risultati hanno suggerito come l'OI applicato a progetti generici sia un argomento ampiamente discusso che trova conferma in letteratura, ma alcune lacune rilevanti sul contributo dell'OI su Net Zero e le competenze e le capacità necessarie per intraprendere questi progetti sono state colmate con il contributo delle interviste. Questa tesi fornisce alcuni contributi rilevanti alla letteratura: una raccolta di alcuni aspetti positivi e negativi molto specifici dell'OI nel campo del Net Zero, affrontando i vantaggi, i limiti, il valore del network, la cultura interna e un'analisi delle

competenze e delle capacità necessarie da parte delle aziende per intraprendere progetti Net Zero con l'aiuto di partner esterni.

1 Contents

2 Introduction

The world is facing a very threatening decade: a period in which we can already see the effects of climate change on our lands, on our cities, on our habits.

Climate change is driven by anthropogenic activities and caused by a large quantity of yearly GHGs emissions (nearly 51 Gt of CO2eq in 2020), that **are not going to drop in the short/medium-term** (Rockström et al. 2009)**.** Our budget of emissions to keep the average temperatures under +2°C is saying that at this rhythm of yearly emissions we have 10 years before the almost certain passage to +2°C on average.(IPCC_AR6_WGIII_TechnicalSummary, 2022)

We must act, as human beings and as a specie, and to do so we must tackle the most important sectors in which emissions are present.

Open innovation was firstly discussed by a famous book in the early 2000's called "*Open Innovation: The New Imperative for Creating and Profiting from Technology*" (H. W. Chesbrough 2003) by Henry William Chesbrough.

The other main theme of this research is Net Zero, which is the political will of an entire continent to be net-zero-emissions by 2050.

This will require an enormous number of investments and disruptive changes into our society, for a simple reason: almost every part of our everyday life is involved in this discussion, as CO2 emissions are strictly connected and correlated with economic growth and almost every type of process that requires energy to be done. (Sovacool, Iskandarova, e Geels 2023)

In the next paragraphs these two main topics of this research will be explained, to assure a minimum level of knowledge:

- Open Innovation

- Net Zero

Open innovation and Net Zero **have never been studied systematically together**, as OI is a wide-spread method to innovate processes and products in different industries, but Net Zero is a topic that comprehends itself every aspect of society, so the connection between the two themes has never been analyzed by literature.

In this research, after presenting the two topics, the aim is to find a comprehensive understanding of how OI could contribute to solve the Net Zero challenge.

2.1. Open innovation

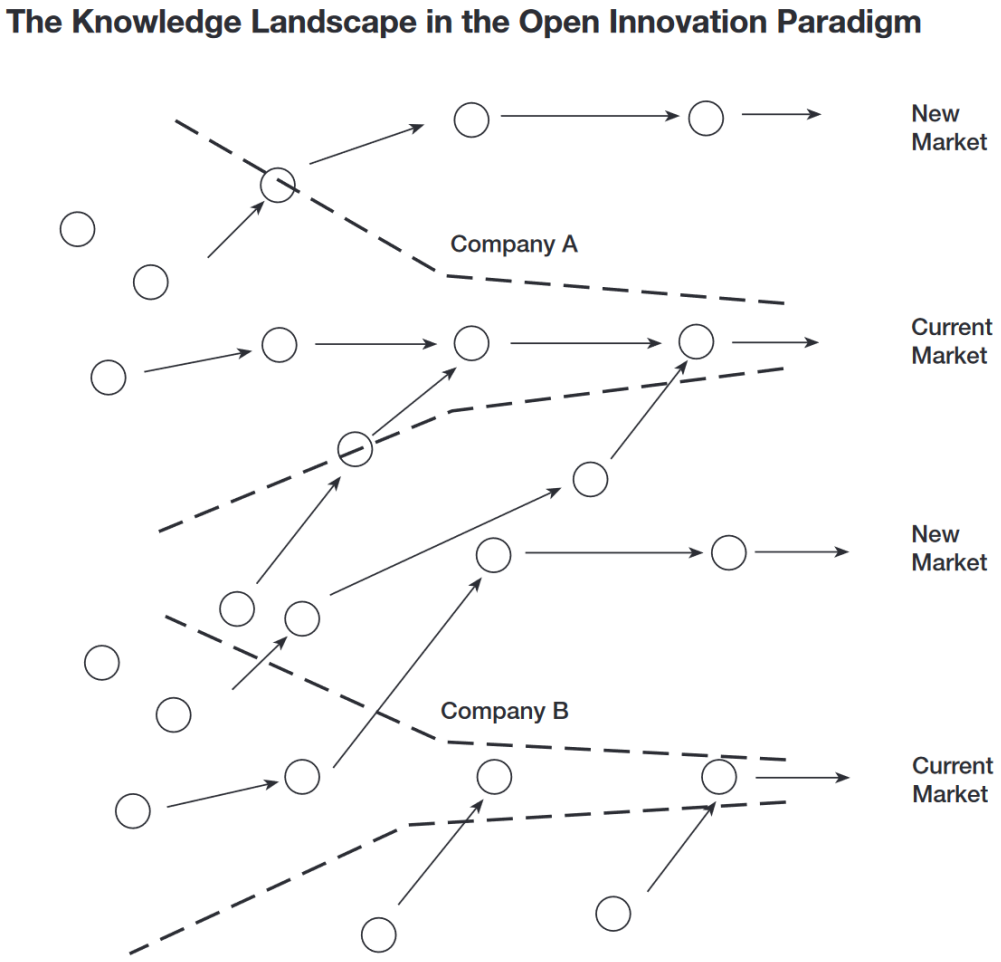

Figure 2-1 Open Innovation paradigm

Open innovation is an organizational collaborative model type that has been gaining increasing attention in the past years, essentially due its measurable benefits in **enhancing the innovation capacity of organizations.** Essentially, open innovation means that **organizations should work together in networks of collaboration, sharing ideas, experiences, know-how, and technologies, to generate value that otherwise could not be achieved if organizations work in an isolated mode**.(Ober 2022)

Open Innovation means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well(H. W. Chesbrough 2003)**.** This approach places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths to market during the Closed Innovation era. Ideas abound in this environment, not only within each firm, but also outside the firms. These ideas are available to be used, and often the people who created them are similarly available for hire.

It represents an organizational innovation that can enable firms and the industry itself to structure their innovation processes more effectively and efficiently, significantly reducing the cost, time, and thus the risk of innovation.(Bigliardi et al. 2023)

The availability and quality of these external **ideas change the logic that led to the formation of the centralized R&D silos of the Closed Innovation paradigm.**(H. W. Chesbrough 2003)

'Net Zero emissions by 2050' is the new target for climate policy, following the goal stipulated in the 2015 Paris Agreement of 'holding the increase in the global average temperature to well below 2 ◦C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 ◦C above pre-industrial levels. (Ekins et al. 2022)

In 2021, the UN 's Intergovernmental Panel on Climate Change (IPCC) released a "Code Red" for humanity, stating: "The alarm bells are deafening, and the evidence

is irrefutable: greenhouse-gas emissions from fossil-fuel burning and deforestation are choking our planet and putting billions of people at immediate risk."(Erla Jonsdottir et al. 2023)

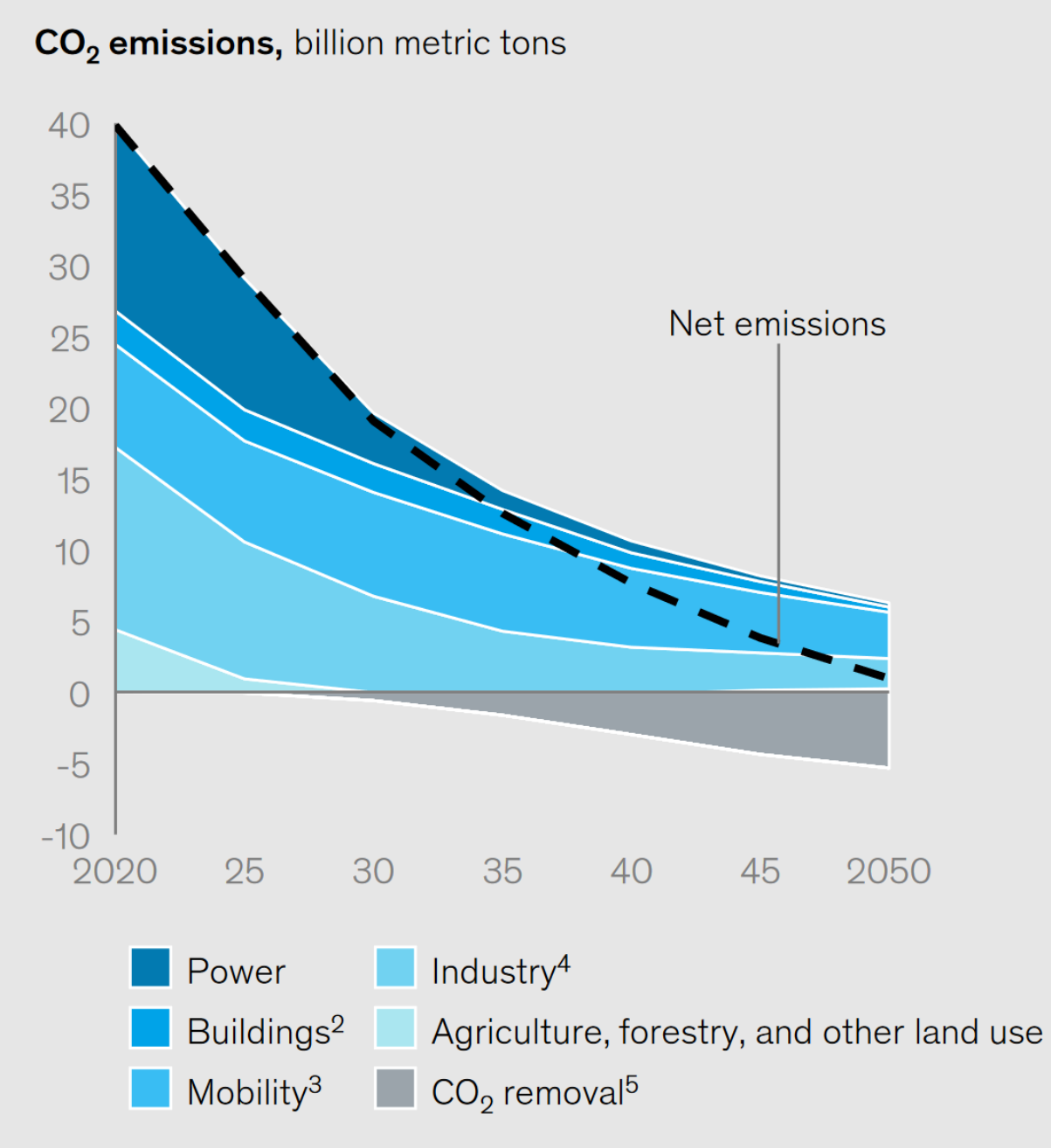

Figure 2-2 McKinsey report shows the necessary emissions path to reach Net Zero

More than 10,000 years of continuous and accelerating progress have brought human civilization to the point of threatening the very condition that made that progress possible: **the stability of the earth's climate**. The physical manifestations of a

changing climate are increasingly visible across the planet, as are their socioeconomic impacts. Both will continue to grow, until the world transitions to a net-zero economy, and unless it adapts to a changing climate in the meantime. No wonder, then, that an ever-greater number of governments and companies are committing to accelerate climate action. (The-net-zero-transition MCKINSEY, 2021)

Anthropogenic climate change is now beyond dispute, and in the run-up to the climate negotiations in Copenhagen, the international discussions on targets for climate mitigation have intensified. There is a growing convergence towards a '2 °C guardrail' approach, that is, containing the rise in global mean temperature to no more than 2 °C above the pre-industrial level.(Rockström et al. 2009)

At present, though, **the net-zero equation remains unsolved: greenhouse gas emissions continue unabated and are not counterbalanced by removals, nor is the world prepared to complete the net-zero transition**. Indeed, even if all net-zero commitments and national climate pledges were fulfilled, research suggests that warming would not be held to 1.5°C above preindustrial levels, increasing the odds of initiating the most catastrophic impacts of climate change, including the risk of biotic feedback loops. **Solving the net-zero equation cannot be divorced from pursuing economic development and inclusive growth**. It would require a careful balancing of the shorter-term risks of poorly prepared or uncoordinated action with the longer-term risks of insufficient or delayed action.

Achieving Net Zero would mean a **fundamental transformation of the world economy**, as it would require significant changes to the seven energy and land-use systems that produce the world's emissions: power, industry, mobility, buildings, agriculture, forestry and other land use, and waste.(The-net-zero-transition MCKINSEY, 2021)

As a result, estimates of the annual spending on physical assets for a net-zero transition exceed to a meaningful degree the **$3 trillion–$4.5 trillion total spending estimates** that previous analyses have produced.

Governments, companies, and other institutions increasingly recognize that the physical risks associated with a changing climate will continue to build up until the world reduces greenhouse gas (GHG) emissions and counterbalances any remaining emissions with equivalent removals of GHGs from the atmosphere. To do so world will require decarbonizing six energy and land-use systems:

- Power
- Industry
- Mobility
- Buildings
- Agriculture
- Wasteland
- Restoring a seventh, forestry and other land use, that acts as both a source of and a natural sink for CO_2 and other greenhouse gases. (The-net-zero-transition MCKINSEY, 2021)

2.2. Problem statement

From literature it is still not clear **what is the connection between OI and Net Zero**, so the above-mentioned topics will be tackled trying to fine an intersection between them.

The phenomenological relevance of these above-mentioned topics is evident: Open innovation is a widespread method to innovate products and processes, while Net Zero will deeply transform our society in the next decades, under a variety of aspects, most of all the method through which we will use energy .

The gap in knowledge is the contribution of open innovation to Net Zero projects, **a connection which is not clear from the state-of-the-art literature.**

2.2.1. Aim and research questions.

The aim of this research is to study the contribution of Open Innovation on Net Zero, and to find the capabilities and skills needs by companies to undertake Net Zero projects.

To better understand these topics, this research will pose **two relevant research questions**:

- What is the contribution brought by Open innovation on net-zero?
- What are the capabilities and skills brought by open innovation on Net Zero?

Literature review will be based on these main aspects of the above-mentioned topics:

- The contribution of OI on a generic company's path of innovation, regarding:
    - Benefits of OI.
    - Limitations of OI.
    - Specific contribution regarding sustainable transition or Net Zero.
- The capabilities and skills scouted in an external partner by companies in OI, undertaking Net Zero projects.

3 Literature review

The aim of this chapter is to give an overview of the **state-of-the-art literature** in the field of Open Innovation and Net Zero, and try to find intersection between the two topics, to answer to the previous-mentioned research questions.

Open innovation is a widely spread method to innovate processes and products, so literature about this area is wide and complete: the aim of this thesis is to investigate the contribution of OI in generic projects and with a specific attention to Net Zero and sustainable transition.

The second aim of this literature review is to give an overview about a specific issue: the competences and skills that a company pursuing OI is searching on the market, to undertake Net Zero projects, or projects related to sustainable transition.

In this field, **literature is extremely poor** and without a clear definition of what are the necessary competences needed by companies to undertake these projects, leveraging on OI tools.

3.1. Contribution of Open Innovation on generic projects

Literature review about the contribution of Open Innovation to the undertake of generic projects in different industries is broad and well-studied, but **there is a gap in knowledge about the specific contribution that OI can give to the sustainable transition and Net Zero.**

In the next paragraphs, benefits and limitations of OI connected to generic projects will be analyzed, and **specific aspects regarding Net Zero and sustainable transition** will be tackled, to give an overview of the intersection of the two topics.

3.1.1. Table of sources comparison

Source	Benefits	Limitations
(Nunes e Abreu 2020)	• Allows to knowledge, ideas, technology flow in and out between organizations. • Diversification of R&D investments • Easier market entry • Resource acquisitions advantages • Development performs at a higher pace. • Broader base of ideas • Technological synergy effects • Increase of the learning capacity • Use intellectual non-own property as strategic asset.	• Increase in process coordination and implementation costs. • More faults in routine workflows • Strong dependence on external knowledge • Loss of key knowledge control and flexibility, creativity, and strategic power • Lack in legacy for additional tasks • Risk of leak, of confidential information • Loss of overall control over the innovative process and intellectual property (IP)

	• Reduced costs of innovation initiatives • Share innovation investments risks with other partners • Increase differentiation and the creative process. • Create new revenues streams (Copyright-royalties)	
(Ullrich e Vladova 2016a)	• Diversification of R&D investments • Easier market entry • Resource acquisition advantages (organizational) • Broader base of ideas • Technological synergy effects • Improvement of the internal learning capacity through the	• Process coordination costs • Implementation costs • More faults in routine workflows (organizational) • Strong dependence on external knowledge • Loss of key knowledge control • Loss of flexibility, creativity, and strategic power (knowledge management) • Lack in legacy for additional tasks

	transfer of external knowledge and learning routines (knowledge management) • Use of intellectual property as strategic assets • Monitoring of the uncertainty of value and protection level of others' patents (legal)	• Intellectual property spillover • Various levels of contractual experience compared to big enterprises (as potential partners)
(Open Innovation Model | Sinnaps - Cloud Project Management, 2022)	• Creating new products and services • Innovating old products and services • Building a strong network and community of people who are engaged with your work	• Possibility of revealing information not intended for sharing • Potential for organizations hosting to lose competitive advantages as a consequence of revealing intellectual property • Increased complexity of controlling information • Regulating how contributors affect a project

	• Keeping your employees engaged • New revenue streams • Innovation risk reduction • Reduced cost of conducting research and development • Potential for improvement in development productivity • Early incorporation of customers early in the development process • Increase in accuracy for market research and customer targeting • Greater synergistic potential with both internal and external innovations of the organization	• Devising means to properly incorporate and identify innovation • Realigning innovation strategies to extend beyond to get the full benefit from the innovation on the external side of things.

	• Marketing potential	
(Ober 2022)	• Ability to communicate externally with the recipients of my products/services • Reducing time to market of the product/service • Reduction of operating costs of the company • Supporting the team process of software development • Sharing of intellectual property rights to software • Complementing each other's different skills when collaborating with external partners • Acquisition of external partners for cooperation	• Insufficient support from top management • Reluctance to share knowledge. • Communication barriers • Lack of internal commitment to the company • NIH syndrome • Rigidity of work organization • Organizational/administrative barriers • Negative attitudes toward open innovation • Legal barriers

	• Ability to share knowledge. • Access to innovative technologies	

Table 3-1 Examples of some benefits and limitations of OI in generic projects found in literature

In the next table, main benefits and limitations regarding OI in generic projects will be summarized.

Benefits	Limitations
Knowledge base (new ideas, technology and market)	Coordination costs/alignment of resources
Internal synergies with R&D	Strong dependence on external knowledge
Faster go to market process	Possibility of leakage of important information
Lower risk in approaching new markets.	Commitment of top management
Strategic lever to achieve competitive advantage.	Lack of internal culture

Network intra and inter organizations.	
Internal lever to foster culture and awareness about innovative topics	

Table 3-2 Summary of main benefits and limitations of OI on generic projects

3.1.2. Benefits

3.1.2.1. Knowledge base (new ideas, technology, and market)

One of the main advantages of OI is the possibility of leveraging on **external knowledge to bring value to the organization**, and obviously competitive advantage to it.(Nunes e Abreu 2020; Ober 2022; Ullrich e Vladova 2016a)

This contamination comes from three main clusters of inputs:

- Ideas
- Technology
- Market

Ideas can bring value to the company by expanding the horizon on which managers can decide which is the best way to maintain competitive advantage, technology can bring new products or paradigm upon which companies can create new partnerships or products, and market gives the idea of new possibilities of revenue streams, and so profitability for the entire company.

In a RCBV, knowledge is fundamental to give a competitive advantage to the company, as it leverages on internal resources and competences to see the value of an organization.(Lima Rua, Musiello-Neto, e Arias-Oliva 2022)

Knowledge management capability moderates the mediating mechanism of organizational learning through which open innovation contributes to sustainable

competitive advantage. In line with the RCBV that outlines the importance of knowledge in generating competitive advantage, this source shows that **the high level of knowledge management capability can be an enabler helping open innovation creates competitive advantage**.(Zhang et al. 2023)

A firm with high level of **knowledge management capability can benefit from open innovation**, but one with low level of knowledge management capability may fail to translate open innovation into performance. Improving knowledge management capability is an important task for managers who leverage OI to create sustainable competitive advantage.(Zhang et al. 2023)

3.1.2.2. Internal synergies with R&D

Open innovation has always been seen as the antagonist to the traditional closed approach based on R&D departments which could exploit their internal competences to build new innovative products that were much more significantly better than competition.

In this old and traditional view, the internal competences were a strong lever for competitive advantage.

Nowadays, due to some changes in global economy, such as intermobility of workers, internationalization of markets, easier access to knowledge and openness of companies to innovative activities, **OI approach is much more used and widely spread among big corporations.**(H. W. Chesbrough 2003)

The main advantage from sources is the synergy that could be created with R&D department, to build new products and combine internal and external innovation activities.(Nunes e Abreu 2020)

One main example comes from the most leading pharmaceutical companies build their R&D organizations on traditional OI processes in combination with external networks.

Leading pharmaceutical companies needed to find a way to bridge the gap between their own culture and that of their partners.

This problem could be solved by creating new internal R&D structures like those of smaller biotech companies or academic partners. Good examples are the Innovative Medicines and Early Development (IMED) Biotech Unit of AstraZeneca or Chorus, a subsidiary of Eli Lilly.

The examples of Bayer and AstraZeneca illustrate that OI can be effectively implemented with a well-defined strategy. COVID-19 pandemic acted as a catalyst for transformative collaboration. Besides giving digitalization a push, **the search for a vaccine and therapeutic drugs stressed the power of multi-lateral R&D collaborations.** The prime example of the mRNA technology space, exemplified by the Pfizer BioNTech vaccine Comirnaty, demonstrates how innovation can happen when **combining existing ideas and technologies in an open manner**. COVID-19 vaccines and, in the meantime, therapeutics **could not have been developed so quickly if governments, academia, and industry had not have collaborated so closely and shared knowledge, resources, and competencies in such unprecedented ways.** Inspired by these unique ways of collaborative R&D, the challenge remains to leverage innovation frameworks, such as OI, to design and develop drugs in a faster, smarter, and more agile manner. (Schuhmacher et al. 2022)

3.1.2.3. Faster go to market process

One of the main advantages from OI is the faster go to market process, which allows firms to undertake new investments on new products more effectively and with a higher speed compared to a normal new product development process.

The reason behind this important contribution could be found in the higher openness of OI firms into their competitive landscape, that is a source of ideas, knowledge and practices, very useful to make these companies know which are the best practices and processes needed to have market success with a new product.

In literature, OI practices have been found to be strictly connected and correlated with a successful **new product development process** (NPD): (Zhu et al. 2019) explored the effectiveness of OI on NPD speed by differentiating two OI strategies, the horizontal strategy (OI breadth) and the vertical strategy (OI depth). In addition, by identifying BM as the critical contingent factor, he investigated the moderating effect of BM on the OI–NPD speed relationship. More importantly, he furthered clarify how a specific matching between different BM types and OI strategies drives NPD speed. The empirical results show **that both OI breadth and depth have positive effects on firms' NPD speed and that such effects are contingent on BMs**. The findings also confirm that different types of BM (i.e. efficient and novel) must be aligned with OI breadth and depth to better facilitate NPD speed.(Zhu et al. 2019)

3.1.2.4. Lower risk in approaching new markets.

One of the most important and beneficial contribution of OI on generic projects is the lower risks in approaching new markets: openness means exchange of ideas, practices and processes between firms of similar or different industries.

Normally, new investments in a new market means risk of failure or risk of wrong timeline with the right product.

OI's main advantage is to create an ecosystem in which managers can exchange opinions on suppliers and past projects that could have had wrong consequences on the business. This can strongly decrease the possibilities of making wrong decisions and learn by others' past experiences.

In literature, the relationship between open innovation and corporate risk management has been supported by results.(Lima Rua, Musiello-Neto, e Arias-Oliva 2022) **Innovation is risky and, unless the process is carefully managed, there is a high failure rate between the initial idea and the launch into the market of a product/service** (Tidd J., Bessant J., Pavitt K. 2007). Top management's responsibility is to identify how to deal with corporate risks to achieve the firm's objectives with

greater certainty (Lassen e Laugen 2017). Open innovation's positive and significant effect on organizational strategy was confirmed. The key element of a firm's business model is the identification of how to profit from innovation; the development of new products must be aligned with strategies about "going to market" and "capturing value" (Musiello-Neto et al. 2022). The business model should transform ideas into profits and recognize that innovative firms should not rely only on internal knowledge; they should not depend exclusively on the knowledge held by their employees but should seek to acquire external knowledge(H. W. Chesbrough 2003)

The results of the study conducted by (Lima Rua, Musiello-Neto, e Arias-Oliva 2022) confirmed the mediating effect of corporate risk management on the relationship between open innovation and organizational strategy. (H. Chesbrough e Crowther 2006) argue that open innovation tools must follow the firm's strategy and enhance collaboration with external partners. **Corporate risk management allows firms to safely integrate open innovation into their business models** (H. W. Chesbrough e Brunswicker 2014). However, open innovation creates different risks for different firms; they should seek to develop mechanisms to address the various risks to facilitate new product development and increase business volume(H. W. Chesbrough 2003). Innovation practices directly impact firms' strategies and create additional opportunities, for example, access to knowledge, resources, markets and external skills, reduced product development time/cost, risk-sharing and faster market launches.(H. Chesbrough e Crowther 2006; Lima Rua, Musiello-Neto, e Arias-Oliva 2022)

3.1.2.5. Strategic lever to achieve competitive advantage.

OI is considered a strategic lever to sustain competitive advantage.

It allows speed, effectiveness, an intensive source of knowledge from external environments, which allow firms to have a higher speed on the market and reach rapidly new technologies and in the end, competitive advantage derived from them.

According to the research from (Lima Rua, Musiello-Neto, e Arias-Oliva 2022), results showed a relationship between open innovation and competitive advantage. Firms need to identify and understand trends in emerging technologies and **expand their technical knowledge base into developing and maintaining cutting-edge technologies that create competitive advantage** (Distanont et al. 2018). A solid strategic approach allows organizations to build long-term competitive advantage, bringing together knowledge, technological skills, creativity, experience, and growth by introducing new ideas in innovative products, processes, and business models. These insights benefit the organization and promote economic growth.(Calabretta, Gemser, e Wijnberg 2017; Lima Rua, Musiello-Neto, e Arias-Oliva 2022)

In a RCBV, (Lee e Yoo 2019) states that the ability of maintaining assets and the effectiveness with which they can be utilized is the key to sustain competitive advantage.

The performance of an organization is determined by whether it has core assets and how effectively the assets can be utilized by the organization. In particular, in a rapidly changing environment, the ability to sense and seize intangible assets created by internal and external members, and transforming capability to transform existing knowledge into resources that are used to respond to environmental change is the key sources contributing to the **creation and maintenance of competitive advantage**.(Lee e Yoo 2019)

3.1.2.6. Network inter and intra organizations.

A main benefit deriving from the main definition of open innovation paradigm is the key essence of this practice: **openness and human relationships**.

Network is a key aspect of OI and deals with the possibility of exchanging ideas inside and outside the company to create value for the organization.

This key value **is the basis to build the other above-mentioned aspects of OI**:

- Knowledge base (new ideas, technology, and market)

- Internal synergies with R&D
- Faster go to market process
- Lower risk in approaching new markets.
- Strategic lever to achieve competitive advantage.
- Internal lever to foster culture and awareness about innovative topics.

All these other benefits derive from the network value, which comprehend the internal and external aspects of OI: **you need network to build knowledge, synergies with R&D, a new go to market process, to lower risk, and to build competitive advantage and mostly to create an internal culture for innovation themes.**

One main source ((Tolhurst e Brown 2013)) from Oakland UK described well types of relationships that could be created in OI ecosystem.

Oakland considers that **there are three broad purposes** for establishing a strategic external network for open innovation:

- **Strengthening a core competency that will remain core over the medium to long term**:

The aim of the network is to bring in new thinking and knowledge in a strategically important area that will remain relevant to the business over time. The network may bring in experts from adjacent areas or new geographies to build on and complement established in-house expertise e.g. on a core ingredient or processing technology.

- **Expanding knowledge of generic technology topics that span through the portfolio of products**:

Knowledge of nutrients or health-related issues that are relevant across a portfolio of products can be expanded by external knowledge of technology and/or market developments applicable to an intrinsic need across the different product types. There is likely to be less internal expertise than in the core-competence areas of the company, but it is an area recognized as strategically significant over at least three to five years.

- **Exploring and experimenting in innovative technology or business areas**

As an alternative to internal recruitment or training, which can be risky and costly, some companies have used extended external partnerships to scope and build knowledge in new areas.

there are two main models for strategic external networks for open innovation:

- **Hub and spokes network**

A hub and spokes network involves **a series of one-to-one relationships between a company (the hub) and various external partners that complement the company's capability (the spokes).** Interactions are with individual external partners, and the network members are not brought together. This is the less resource-intense system, and has less risk in terms of IP management arising from the connections than in the ecosystems described below. However, there may be less opportunity for synergies between different topics or insights. This type of network is most appropriate for areas that are close to the core competence of the company and can also be used for expanding generic knowledge or exploring new business opportunities. These one-on-one interactions **help to 'gap fill' the internal knowledge**, problem-solve on specific current issues, and can be vital to keep abreast of developments in the external world. The most appropriate experts within the network are targeted to source knowledge and insight as required.

- **Collaborative, or ecosystem, network**

A collaborative, or ecosystem network involves orchestrating a community of various external partners, with physical or virtual interactions between network members. This model is appropriate where one-to-one relationships do not address the identified needs, and a more holistic perspective of the issues is desired. The combined diversity can be particularly helpful for more complicated areas, that require multiple elements to be combined from different partners and for areas that are further away from core competencies, where internal stakeholders are less likely to already possess great depth and/or breadth of understanding. Although generally requiring greater

input from the company than the hub and spoke model, the ecosystem's value derives from bringing together partners who would not normally interact, giving rise to new, and potentially more disruptive, thinking. The most important factor in both models is that the company plays a central and active role in order not to 'drop out of the middle'. This means that the company does not just derive value from the network, but also gives value back to the partners or ecosystem to remain an active part of the system.

Strategic external networks for open innovation can offer a number of benefits to the innovation process. Bringing in alternative, and broader, perspectives and knowledge from multiple directions can provide both a horizon-scanning function and new solutions to identified problems. In particular, **external partners can offer value when they have a leading edge over the company in a competence area, or when they can provide extra capacity, facilities or capabilities (e.g. external suppliers).** Lateral knowledge flow in an ecosystem-type network can also enable a company to put together different pieces of a puzzle to show the bigger picture. Furthermore, the company can benefit from the reputation of its external partners, and the network can give a higher level of credibility to products and services. This can be especially relevant where there is a need for evidence-based proof of activity and benefit, and in areas where it is desirable to be seen as moving to positive messaging, for example in health, safety or environmental areas.

Using a strategic external network to explore new areas can also help mitigate against risk, particularly in a rapidly changing environment, by enabling a company to change direction relatively quickly without building in too many assets that may then not be relevant. Although it may be more expensive in the short term, there is less overall liability. Furthermore, as it can be difficult to predict the necessary core capabilities of longer-term R&D, the use of floating resources and capabilities provides much more potential to 'future-proof' without hindering the company from exploring ideas. Indeed, some companies have turned down the option of doubling

their R&D capability, believing it is better to keep more flexibility through partnering. Many relationships exist between employees and external partners, but with the increasing trend in employee mobility, personal connections can easily be lost to a company (Ballinger et al. 2011). A formal network can help guard against this. It also provides a facilitated and established route to external-partner views on a particular area or problem as the need arises. One perceived drawback relates to the time and resource input required to set up a network and maintain momentum. One of the key differences between personal and corporate networks is the visible cost. It is possible to leverage more from personal networks without cost, but where a company is leveraging a network in a more strategic way, there is a contractual element with some form of remuneration or commercial expectation, making the cost more tangible. **When setting up external networks with multiple partners, it is important to consider confidentiality concerns**. Many food and beverage products are not highly technically differentiated, so that, in many areas competitors can move in relatively quickly. The risk of sharing internal knowledge and strategy with external partners needs to be managed without overly restricting open-innovation processes. Overall, the company must assess the benefits and drawbacks, to determine whether a strategic external network provides sufficient added benefits to the innovation process to make the resource dedication worthwhile.(Tolhurst e Brown 2013)

3.1.2.7. Internal lever to foster culture and awareness about innovation themes.

Many companies nowadays are trying to interact not only with the external partners, but also with internal resources of the company, to help them undertaking new projects and contribute to the innovation process of the company with new ideas and deep vertical knowledge.

Today's most used practices to help internal people of the company to give a contribution are:

- Call for ideas.

- Hackathons.
- Workshops.

The main benefit deriving from this theme is the possibility **to create an internal innovative ecosystem that can benefit from innovation cultural themes and can give a contribution, thanks to the vertical competences of internal employees**.

They become a really important source of innovation applied to company's processes.

There are many companies that hunt for innovative ideas among the most disparate realities (startups, small and medium-sized enterprises, associations or even individuals) using the call for ideas tool, or a competition of ideas usually aimed at people or companies active in specific market sectors. The organization of the call, as well as the path, the objectives set and the outcomes, vary depending on the company that launched the challenge. It is not excluded that the organizers decide to invest, directly or indirectly, in the realities that have developed the most promising innovations.(Kratzer, Meissner, e Roud 2017)

Some companies may decide to set up hackathons, programming competitions during which they ask developers and programmers to develop innovative digital solutions related to a given sector in a limited period (24 or 48 continuous, in general).

It is also possible that organizations opt for prizes as a way of identifying and highlighting innovative realities that have aroused their interest and with which, if necessary, they intend to continue the relationship.(Kratzer, Meissner, e Roud 2017)

3.1.3. Limitations

3.1.3.1. Coordination costs/alignment of resources

OI involves a lot of people, processes, and directions in a company. This means difficulty in aligning everybody on the direction of the innovative project.

OI can involve people from OI team, different teams inside the mother company, innovation brokers, external partners and maybe also public partners (universities or local entities).

Organizations face coordination constraints when adopting OI. As more people get involved in the process, **there are more people and tasks to balance**. **The collaborative process can also present a challenge for centralized control when there are too many individual innovators involved.** Managers that are unable to navigate this complexity may struggle to lead OI effectively (Gentile-Ludecke, Torres de Oliveira, e Paul 2020). This includes both monitoring of participation and effective integration of contribution (Marullo et al. 2022). Without strong leadership and centralized control, **these partners may struggle to coordinate on a strategy and overall direction**.(Roberts, Palmer, e Hughes 2022; Su, Mcguckin, e Abhari 2022a)

3.1.3.2. Strong dependence on external knowledge

OI means leveraging on external knowledge to create value for the company: this could also mean to leverage more on the external partners than internal resources of the company.

A paradox that could be reached by OI company is to have more external than internal expertise on core business topics.

This could create a difficult situation in which the company can't control the necessary competences that constitute a value for the company.(Nunes e Abreu 2020)

3.1.3.3. Possibility of leakage of valuable information

An environment that does not allow for safe, efficient transfer of information is not one in which innovation can prosper**. Knowledge management, especially when coupled and integrated with external knowledge sources, requires extensive**

security measures to protect the validity and reliability of data. Lack of this security may discourage many OI organizations from sharing their data, particularly in outbound OI, due to security concerns for commercial or industrial exploitation. The security measures demand more even resources from the firm, such as an adequate knowledge management system. Recovering from the mishandling of knowledge and business data in OI may put a further financial strain on the company as a whole.(Su, Mcguckin, e Abhari 2022a)

3.1.3.4. Commitment of top management

Lack of structure can further exacerbate the issues associated with resource allocation (Germonprez et al. 2020). **This could include a lack of hierarchical structure, but also the lack of a formalized internal innovation process** (Oliveira, Gentile-Lüdecke, e Figueira 2022). Without a clearly defined organizational structure, external actors struggle with determining how to contribute meaningfully to the OI process (Germonprez et al. 2020). The organic form of these networks can result in complex relationships between actors that may lead to governance challenges (Haim Faridian e Neubaum 2021). Moreover, a lack of structure within an organically formed network also encourages an abundance of ideas, not all of which can be invested in. **Organizations may face the loss of many opportunities without the infrastructure necessary to give potential solutions generated by OI a chance** (Ovuakporie et al. 2021). Another potential problem related to the lack of well-defined structure is the **assumption of responsibilities among the actors**, especially in hybrid innovation strategy management (Cenamor e Frishammar 2021). While all these factors are considered important constraints, the lack of cooperation within the organization is considered the least important constraint of the OI process (Oliveira, Gentile-Lüdecke, e Figueira 2022)yet it should still be considered as a possibility.(Su, Mcguckin, e Abhari 2022a)

3.1.3.5. Lack of internal innovative culture

A major problem for OI practices is **the lack of internal culture for innovation**, and this certainly is a barrier to OI projects, because alignment of resources is necessary for the success of the project.

A study conducted by (Naqshbandi, Kaur, e Ma 2015) clearly evidences which are the main cultural aspects related to OI.

(Naqshbandi, Kaur, e Ma 2015) **found that highly integrative culture enabled while hierarchy culture retarded in-bound open innovation in the organizations**. Culture is known to support innovation by creating an organizational climate that institutionalizes innovation as an important activity. By focusing attention on innovation, a supportive culture helps to motivate and sustain the complex, interactive process of social exchange necessary for successful innovation (Russell 1989) Culture has often been cited as a major challenge when adopting open innovation and researchers have pointed towards the **significance of organizational culture in the open innovation paradigm**. Creating a culture that values outside competence and know-how is crucial for open innovation practice (Gassmann, Enkel, e Chesbrough 2010). For a firm to make this shift in its approach, organizational culture plays a critical role as it is critical for the integration of organizational processes and adaptation to the external environment. The firms with integrative cultures have widely shared and strongly held values that address their needs of internal integration and external adaptation. By facilitating interaction of firms with their environment, **highly integrative culture enables in-bound open innovation in organizations with such a culture. On the contrary, firms with Hierarchy Culture lay a low level of emphasis on the values that address a firm's needs of internal integration and external adaptation** (Cameron 1985) and thus retard in-bound open innovation. **A highly integrative culture can clearly help in tackling such challenges**

and enabling in-bound open innovation. Moreover, this study revealed no significant relationship between highly integrative culture and out-bound open innovation while hierarchy culture was found to retard out-bound open innovation in the surveyed organizations. The findings are interesting and indicate that **when firms have the resources and technologies and they want to sell them for lack of a fit with their existing business model, highly integrative culture does not play any role.** Therefore, firms may not need to worry about having highly integrative culture to be successful in out-bound open innovation. It needs to be noted here however that there might be certain mediators in the relationship between highly integrative culture and out-bound open innovation, studying which can be a fruitful area for future research. This finding also highlights the sensitivity of handling complex cultural construct at the workplace towards which managers and practitioners should be more vigilant. Future research in this area may help managers identify the type of culture which can help enable out-bound open innovation. On the other hand, going by the findings of this study, **firms need to avoid Hierarchy Culture as not doing so can retard out-bound open innovation. It seems that Hierarchy Culture retards out-bound open innovation for the same reasons it retards in-bound open innovation: that is, it places low importance on the organizational culture values that address a firm's needs of internal integration and external adaptation** (Cameron 1985)

3.2. Contribution of open innovation on Net Zero

From literature, it's clear that every above-mentioned aspect of OI that generates benefits and limitations to the undertake of a project **can be strongly stressed** in the case of Sustainable transition and Net Zero.

Reasons for this can be found in the **difficulty of the themes we are dealing with**, that must be tackled together, with the help of an entire ecosystem.

Net Zero is a broad theme that deals with every single aspect of our society, so the implication for OI is that an open approach is necessary and needed to **reduce risk of failures in innovative projects**

In this paragraph, main aspects regarding the **contribution of OI on Net Zero and sustainable transition** will be analyzed, and the main aim of this piece of literature review is to give an idea of how OI can enhance or block the adoption of Net Zero projects in companies.

3.2.1. Table of sources comparison

Source	Specific aspects regarding OI and Net Zero
(Greco, Locatelli, e Lisi 2017)	• Increase integration to R&D • Increase R&D productivity. • Lower investments' risks
(Kennedy, Whiteman, e van den Ende 2017)	Reduce the risk of innovation in four ways: • access to the new raw material (biomass), but also improved product development and shared risk • valuable market knowledge through 'technology super-scouting' • valuable market knowledge through 'technology super-scouting' • working with external institutions to acquire scientific knowledge that reduced the complexity of developmental decision making
(Pichlak e Szromek 2021)	Interorganizational cooperation to create eco-innovations

(Stephan, Anadon, e Hoffmann 2021)	Knowledge spillovers between same industry companies in deep tech sectors (es. LIB Lithium-ion batteries)
(L'Open Innovation come modello di gestione della conoscenza per facilitare l'eco-innovazione, 2022)	Startup collaboration Knowledge base
(Montresor, Ghisetti, e Marzucchi 2013)	• Collaboration to achieve knowledge in manufacturing. • Trade off emerging with internal R&D • Network value for collaborating. • Too much outsourcing can decrease knowledge base of the company
(De Marchi 2012)	• Internationalization has a positive effect on environmental performance. • Vertical competences are needed and must be strong

Table 3-3 Summary of contribution of OI on Net Zero

Open innovation is the method with which companies pursue eco-innovations, environmental innovations, and Net Zero projects.

The main aspects that OI can stress from a generic project to a Net Zero committed project are:

- The possible integration and synergy with R&D to pursue faster innovation.
- Lower investment risk in innovation, caused by the presence of innovative technologies and not well-known processes.
- Network value, which can decrease the risk of innovating towards wrong directions.

- Internationalization value, which can help creating an ecosystem that can work together.
- Strong vertical competences.
- Outsourcing activity can decrease the ability of a firm to maintain internal competences, to decarbonize entire sectors.

A lot of sources confirm the positive role of OI in pursuing eco-innovation, like (Johanna Ronco, Roberto Pelosi 2013)**: Open Innovation is today considered one of the most promising tools for the development of eco-innovation in companies and society**. The examples we have mentioned certainly do not exhaust the case studies of the possible applications and operating methods of Open Innovation dedicated to the development of eco-innovation, but they can offer a picture of the variety and continuous evolution of this new model of knowledge management. Soon, the selection of "open green innovation" models able to combine eco-innovation with economic sustainability, will represent an important competitive advantage for companies, bodies and institutions, capable of bringing positive effects on the entire territorial system to which they belong.(Johanna Ronco, Roberto Pelosi 2013)

Another source from (Greco, Locatelli, e Lisi 2017) confirms the positive value of OI practice in a difficult sector which is surely involved in the Net Zero transition: Power and Energy sector. The P & E sector faces several R & D challenges all over its domain. These challenges include the development of more cost-effective photovoltaic plants, energy storage technologies, decommissioning and decontamination of nuclear facilities etc. Consequently, **R & D investments in the P & E sector are massive**. Such investments are the result of contingent factors (e.g. the availability of certain technologies), policy decisions (e.g. the introduction of subsidies) or even market trends (e.g. the cost of a certain fuel). P & E firms attempt to identify solutions in order to accelerate the future changes in the energy system. On the other hand, **the nature of the energy market and the nature of the learning curve request the intervention of policy makers** to make the innovations feasible. In this perspective, **enhancing the**

OI paradigm adoption may concur in increasing the firms' R & D productivity and have substantial social spillover benefits. P&E firms that open their innovation process can share costs and risks, making the technological breakthroughs more sustainable. This might encourage P & E firms to attempt research programs aimed to develop **radical innovations, which are often very expensive and not always attractive to firms operating in the P & E sector**. Indeed, in this sector, while research institutions are specifically interested in collaborating with firms to develop radical, breakthrough inventions, **firms are apparently more lured by researches aimed to develop incremental, low-risk innovation**.(Greco, Locatelli, e Lisi 2017)

(Pichlak e Szromek 2021) states that OI can enhance the possibilities of creating eco-innovations: Creating eco-innovation is dominated by strategic and operational upstream cooperation (with customers). Such results prove that in eco-innovation, the customers of new technological solutions are actively involved; thus, becoming real partners for surveyed companies. **Companies which collaborate with external partners are much more likely to generate a radical eco-innovation than an incremental one. These results confirm other studies** (Mousavi, Bossink, e van Vliet 2019)**, indicating that increasing interdisciplinary collaboration i**n 15 developing new technologies is an important condition for developing such eco-innovation. This is because external partners have valuable knowledge resources that companies can use to complement internal innovation activities (Hutton, Demir, e Eldridge 2021). **Moreover, creating eco-innovation requires developing new knowledge and, last but not least, sharing it within the organization**. In this study, in 89% of companies, members intensively exchange information and learn from each other. It is also a significant inspiration to raise the importance of this process to the level of **inter-organizational cooperation as part of developing open innovations,** both in the context of offering unused technologies and acquiring innovations developed outside the enterprise. It therefore seems important to **combine eco-innovations and the concept of open innovation; thus, creating open eco-innovations**. Such pro-

ecological activities, especially in the area of offering open eco-innovations, can make a significant contribution to the development of global ecological solidarity, aiming at common sustainable goals. (Pichlak e Szromek 2021)

A source from (Kennedy, Whiteman, e van den Ende 2017) posed the accent on the intersection between **OI and sustainability**: Over the past decade, traditional innovation literature has emphasized the importance of going beyond the firm's organizational boundaries to help develop new products through open innovation (H. W. Chesbrough 2003). Organizational sustainability scholars have identified the importance of collaboration for SOI due to its added complexity and uncertainty (Adams et al., 2015), and have begun to consider how **the relationship between open innovation and sustainability is synergistic**. Our case contributes to these discussions by providing empirical evidence on how a SOI process for a radical new product was enhanced by a company's strategy for open innovation involving internal and external parties. Findings suggest that **open innovation created a combined internal and external space for organizational practices, enabling an externally-oriented approach to their respective execution. This critically reduced the risk and uncertainty of radical product SOI in four keyways.** Firstly, changes to the raw material (fossil-fuel) inputs for production were required (De Marchi 2012) By forming a joint venture partnership with a supplier, **DSM ensured access to the new raw material (biomass), but also improved product development and shared risk**. Secondly, the firm acquired **valuable market knowledge through 'technology super-scouting'**, an innovative practice that gathered information on the size of the market opportunity and potential value propositions. Thirdly, the firm was able to source ideas by **engaging with industry experts interested in new bio-based products**. For example, a discussion session was held to successfully solve the technological problem of creating a new sustainable production route. Finally, the firm practiced open innovation by **working with external institutions to acquire**

scientific knowledge that reduced the complexity of developmental decision making, and again reduce business risk.(Kennedy, Whiteman, e van den Ende 2017)

(Johanna Ronco, Roberto Pelosi 2013) stresses the importance of OI in the real context of projects undertaken by big corporations: **Today there are numerous Open Innovation initiatives aimed at the development of clean technologies and involving large industrial companies**. The first and perhaps most famous case is represented by **GreenXChange21**, an organization born on the initiative of Nike and which currently involves important companies such as Best Buy and Yahoo! GreenXChange aims to share patents and ideas to help companies reduce their environmental impacts. The idea dates back to the early 2000s, when Nike developed a "green rubber" with an extremely limited environmental impact, but not suitable to be used for the company's products. After extensive internal consultation, Nike decided to license its technology to Mountain Equipment Co-op, a Canadian company. **What pushed Nike to deprive itself for the first time of its own research result for the benefit of an external company (albeit with an economic return), was a simple concept: if you have a good idea for the environment, but for various reasons you cannot develop it, you must allow someone else to do it**.

The energy sector has also embraced the practices of Open Innovation for the development of cleaner technologies. In 2010, for example, **General Electric and some Venture Capital investors launched an Open Innovation initiative called Ecomagination Challenge**, in which companies, entrepreneurs, inventors and students are involved. According to the father of Open Innovation, Henry Chesbrough, with this initiative General Electric has created the conditions to become one of the world's leading players in the clean energy sector, with a strategy aimed at keeping most of the R&D activity in-house, integrating it with specific expertise from outside23. The initiative provides funding of around $200 million and involves, among others, Carbon Trust, a non-profit association. But the examples do not stop

there: **Shell is also carrying out a research program aimed at sustainable mobility and the study of alternative fuels, through a model based on the principles of open innovation called Open Innovation toolkit**. In addition, in September 2013 the energy French giant EDF - Électricité de France, also presented its Open Innovation strategy at the ECO13 conference in Berlin. EDF has decided to adopt **Open Innovation for the development of clean technologies for mobility**, and thanks to this approach today the charging unit for electric cars designed by the Berlin-based startup Ubitricity is being tested at the EDF25 research and development laboratories.

Finally, the case of the **Italian ENI is emblematic, which is increasingly moving towards the adoption of Open Innovation as an alternative to consolidated outsourcing practices**, with the aim of increasing its capacity to produce innovation. In another sector, the US innovation accelerator Cleantech Open, recently partnered with PARC, a company of the Xerox Corporation, one of the largest manufacturers of printers and copiers. The collaboration is aimed at promoting the development and professional training of startups operating in the renewable energy sector, offering support both for business development and for the creation of prototypes. Finally, we cannot forget the numerous Open Innovation initiatives launched by Google in the environmental field, including the Climate Savers Computing Initiative and the Green Grid, two groups that aim to raise the standards of efficiency and sustainability around the world.(Johanna Ronco, Roberto Pelosi 2013)

(Montresor, Ghisetti, e Marzucchi 2013) deals with the importance of OI mode with respect to the propensity of creating green innovations.

Firms benefit from an open innovation mode to become eco-innovators. Favoring knowledge exchanges and networking among firms and other organizations could have a significant impact on companies' contribution to a sustainable kind of growth in Europe and adoption of **clean production methods in manufacturing**.

Firms' propensity to eco-innovate decreases when, in order to do so, they excessively increase the openness of their knowledge sourcing. Policy support to

innovation cooperation in the field could be conditioned by the size of the relevant network. Green-knowledge platforms, for example in specific manufacturing sectors or regional contexts, should not be too widely promoted and possibly delimited to relevant communities of practitioners. On the other hand, the cognitive and organizational efforts required by deep knowledge sourcing could conflict with that required by its internal assimilation.

With respect to the decision to eco-innovate, a trade-off emerges between the firm's engagement in creating and exploiting internal knowledge through R&D and organizational investments and its engagement in stable (deep) external relationships. R&D supporting policies to environmental innovations should carefully consider this trade-off and the possible crowding out it could entail on the firm's capacity to interact deeply with external knowledge providers. Additional evidence with policy-relevant implications emerges by looking at the environmental innovations portfolio of existing eco-innovators in Europe. In general, the constraints referred to earlier with respect to new potential eco-innovators are attenuated in this case, showing the importance of having an environmental knowledge base for expanding eco innovation activities

Eco-innovators benefit from knowledge sourcing unconditionally when they try to enlarge their portfolio of environmental innovations. Policy support to knowledge interactions could be expected to enable these firms to become more widely eco-innovative, especially by providing them with incentives to consolidate successful partnerships.(Montresor, Ghisetti, e Marzucchi 2013)

(De Marchi 2012) states that R&D cooperation is more intense for environmental innovators than for other innovators, supporting theories asserting that environmental innovations imply higher interdependencies with external partners, because of their systemic, credence and complex features. Furthermore, results

suggest that some categories of partners the firms co-innovate with are more effective than for other innovators.

Suppliers **emerge as very important partners, corroborating theories asserting the presence of technological interdependencies on knowledge, skills and resources that arise in the development of environmental innovation**. Similarly, scientific agents – including universities, consultants and research centers – appear as cooperation partners that are even more important than for other innovations. **The complexity to handle sustainability issues may induce firms to rely to a greater extent than for other innovations on those partners, which may provide knowledge intensive competencies**.

Conversely, the variable indicating the presence of cooperative agreements with users was not significant, suggesting that their relevance does not vary between the development of green and non-green innovations. This result should not be surprising: **environmental features are often not easily detectable by end users and may require very sophisticated technical knowledge to be tackled.** As far as the internal R&D effort is concerned, the results suggest that environmental innovators do not differ from other innovators in terms of resources devoted to R&D activities but rather for the implementation of those activities on a continuous basis. Moreover, results support the existence of a substitution effect between internal R&D activities and R&D cooperation with external partners. The analysis confirms that **firm's characteristics and internationalization strategies affect environmental innovation propensity. In particular, results suggest that size positively affects eco-innovation propensity and that firms that already introduced new products or processes in the past are more prone to introduce environmental than other types of innovation.** Furthermore, results suggest that the policy action, in the form of public grants, fosters innovations that reduce the impact on the environment to a higher extent than other innovations. Interestingly, **serving an international market emerged to be significantly and negatively correlated with green innovation**.(De Marchi 2012)

3.3. Competences/skills scouted by companies in OI on Net Zero

In this paragraph, **main capabilities and skills of companies scouted by OI processes will be analyzed**, regarding very specific aspects found in literature.

In this field, there's a **big gap in knowledge due to the very specific nature of this research**: we're trying to investigate which are the competences that OI companies are scouting on market to reach Net Zero emissions/sustainable transition.

3.3.1. Table of sources comparison

Source	Type of external partner	Sector/field	Type of capabilities/skills	Core capabilities
(Kurniawati et al. 2022)	External partner	Material engineering	**changing the use of synthetic fabric dyes to natural dyes**	Material engineering
(Green business opportunities and Net Zero | McKinsey, 2021)	Generic external partner	Hydrogen/Ammonia	Technical	Hydrogen infrastructure

(Stephan, Anadon, e Hoffmann 2021)	External employees	LIB (Lithium-ion-batteries)	Technical	Batteries technology
(Dudnik et al. 2021)	External partner	AI	Technical	AI for energy efficiency
(Calvo, Monje-Amor, e Villarreal 2022)	External partner	Energy efficiency	Technical	Energy efficiency

Table 3-4 Summary of Net Zero capabilities and skills scouted by companies

Open innovation practices require scouting of solutions with the aim of getting external knowledge and leverage on it, to build competitive advantage.

Scouting of external partners require deep understanding of competences and skills that can complement internal resources, to achieve Net Zero with very specific projects.

Literature in this field is poor and not well developed, but some sources tried to investigate which could be the most important competences scouted by OI companies, to pursue innovation and Net Zero objectives.

According to (Hakovirta et al. 2022)**, corporations must constantly attend to their products and processes of the past while also being able to move forward and build future business growth and stability**. This balancing act of short- and long-term value creation is highly challenging for many companies, especially in the more mature businesses.

Similarly, mitigating GHG emissions for companies is a balancing act of maximizing the returns on past capital investments and securing the future with new technology platforms and business models. Organizations and leaders need to therefore act in an ambidextrous way, **exploring new opportunities while diligently exploiting**

existing capabilities (Alvares, Barbieri, e Morais 2021). This task is challenging especially if companies are using only internal resources and therefore fixed capabilities that can also strongly define the future direction; past performance can many times predict future direction. **From this perspective, one of the major benefits of any start-up company, in its early stages, is that they are able to align the strategy with structure, competencies**. This creates much-needed degrees of freedom in operating many times in an unknown business environment. The companies that tend to be larger, be older, and be in a more stable evolutionary phase are also industrial and have high energy consuming operations that are associated with GHG emissions. These companies are in the center of the GHG mitigation and science-based targets setting. The most GHG-emitting sectors have been identified as electricity and heat production; chemical, metallurgical, and mineral industries (where fossil fuels are used in on-site operations); agriculture, forestry, and land use sectors; transportation (road, rail, air, and marine transportation); and construction and building(IPCC_AR6_WGIII_TechnicalSummary, 2022). **The fact that these sectors are considered as not being the most innovative companies makes climate innovation problematic, and therefore, the role of startup companies can be increasingly important in order to reach the science-based targets that corporations have already committed to.**

The necessary speed for innovation is therefore too slow, and the corporate strategies are not effective in terms of driving climate innovation. Based on our findings, new start-up businesses are in a critical role of accelerating innovation and can therefore drive societal change in environmental sustainability and climate innovation solutions.

Another article ((Dudnik et al. 2021) studied the intersection of OI and AI in the energy market, which is actively moving toward the concept of EaaS, which implies providing new energy services directly to the consumer. EaaS includes consumption management, consumption optimization upon the availability of a local source and

battery, energy exchange through the local grid, or energy savings. In this regard, **energy companies that efficiently use innovative technologies and AI tools will more quickly gain a higher energy sector share.**

Another study ((Calvo, Monje-Amor, e Villarreal 2022)) highlights the importance of designing business models that allow a firm to benefit from collaboration for growth in foreign markets and the potential of eco innovations to address an apparently negative environment into an "external enabler" for a firm's competitive advantage. **Energy efficiency could be a useful focus for future regulations of governments to achieve the environmental goals agreed upon in international conventions.**

Main sector in which these startups are operating could be summarized in:

- Food systems
- Energy grid technology
- Green energy generation
- Electric transportation
- Mobility solutions

4 Methodology of research

Literature is rich about the impact/contribution of OI on generic projects in generic industries, but it is poor considering the intersection of OI and Net Zero, and specifically the skills and capabilities needed to make Net Zero projects reality.

The main contribution of literature to the research questions must could be found in the generic benefits and limitations that OI can give to a company that opens his knowledge to the external partners and tries to capture value from the outside environment.

To get more data and answer in a precise way to both research questions, the best methodology to understand the real contribution of OI on Net Zero and the specific skills and capabilities needed to undertake Net Zero projects was to conduct interviews to experts of this sectors that deeply knew how to deal with these concepts.

This methodology based on interviews was considered the best way to collect data that nowadays are not so studied in literature and widely known in industry fields, so mostly based on widely known opinions of managers, not only scientific papers.

Moreover, interviews were considered fundamental to reach the right data, as the topics in this thesis **cover some empirically evident aspect of OI and Net Zero,** so systematic literature review and case studies were not considered the right method to find the necessary data.(Qu e Dumay 2011)

The sample chosen was made of 20 CIO of big Italian companies that have the expertise to discuss about OI practices applied to generic projects and Net Zero topics.

These big Italian companies all have a sustainable report and obligations to investors, so Net Zero, that is the heart of sustainable climate action of all big companies, is surely a theme with which this chosen sample is dealing with.

This background of these actors was considered an important aspect upon which basing the validity of the data collected in this thesis.

The methodology of research adopted is based on semi structured interviews, with a process that followed these steps:

- Selection of the sample to be interviewed.
- Data collection through semi structured interviews, that followed a path of questions related to the main research questions.
- Data analysis through inductive thematic analysis.

4.1. Selection of sample

Sample was selected among professionals coming from the industry in different sectors (energy, telecommunications, financial services), with the same role: **experts in open innovation dealing with Net Zero projects in big companies** were chosen to represent the sample.

The role of these professionals was the responsible of Open Innovation in the specific case of the company interviewed, normally entitled with the role of CIO (chief innovation officer).

The reason for choosing these professionals was to give an experienced opinion on open innovation and Net Zero topics, thanks to the past years passed conducting numerous POCs on different topics.

The sample is **homogeneous regarding the role of these professionals**, but different regarding some personal characteristics such as background and technical capabilities.

Normally, these managers have in their core activities the management of POC in generic fields or Net Zero-related topics, so their daily activities strongly deal with these topics.

4.2. Data collection

This research was conducted through semi structured interviews posed to innovation managers of 20 Italian big companies operating in different sectors.

Three pilot interviews were conducted to verify the validity of questions and data collection, using these questions:

1. Could you briefly describe the OI process adopted by your company? From the collection of needs to any POC.
2. Why did your company decide to embark on an OI path?
3. What is the value brought by OI in your company in terms of innovation culture?
4. How does Net Zero impact business processes or structures in the specific case of your company?
5. What specific initiatives have been taken by your company in particular?
6. How does open innovation help or complicate work within the company? Positives and negatives
7. How can OI contribute to achieving the company's Net Zero goals?

First results ended up giving a lot of contexts about main OI practices in these companies, but the main disadvantage is the lack of specificity about Net Zero and particularly Net Zero capabilities and skills, which is the heart of the second research question.

Secondarily, main aspects regarding the contribution of OI practices to generic projects were widely discussed in the literature review, so the main aim of the second round of interviews was to deal deeply with Net Zero-related topics, in particular

with the main aspects of OI regarding Net Zero and the capabilities and skills needed to undertake these projects from an external partner's point of view.

Other questions were added to the previous list, to better tackle the **capabilities needed to make open innovation valuable to Net Zero projects in big companies.**

1. Could you describe Open Innovation examples/initiatives regarding Net Zero/decarbonization projects?
2. What was the sector/field of the startup/university/research center?
3. What are the most required skills/capabilities scouted from your company?
4. What was the kind of capability for which you were searching? Technical or organizational?
5. Why are you looking outside you company to find the capabilities you are searching for?
6. What is the contribution of OI in the context of Net Zero projects?
7. How can OI contribute to the creation of a network of big companies to exchange practices, ideas, and projects?
8. How can OI contribute to the creation of an awareness regarding topics related to Net Zero projects?

All the interviewees were granted anonymization.

4.3. Data analysis

After permission for recording was granted, the interviews were recorded, and the conversation transcribed. **Then, the transcribed material was systematically analyzed through inductive thematic analysis**(Braun e Clarke 2006)**.** Content analysis is "a research method for subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh e Shannon 2005). **Advantages of thematic analysis include the fact that it is transparent, unobstructive and flexible**, as it can be applied to a variety of

information. Qualitative content analysis aims to preserve the advantages of quantitative content analysis by applying, at the same time, a more qualitative text interpretation(Braun e Clarke 2006). The transcribed material was reviewed, and a first impression noted. **Then, relevant pieces of the transcript were labelled to allow a preliminary coding.**

The next step was to **finalize coding** according to the above mentioned three clusters of research and try to find some relevant themes to compare findings with literature.

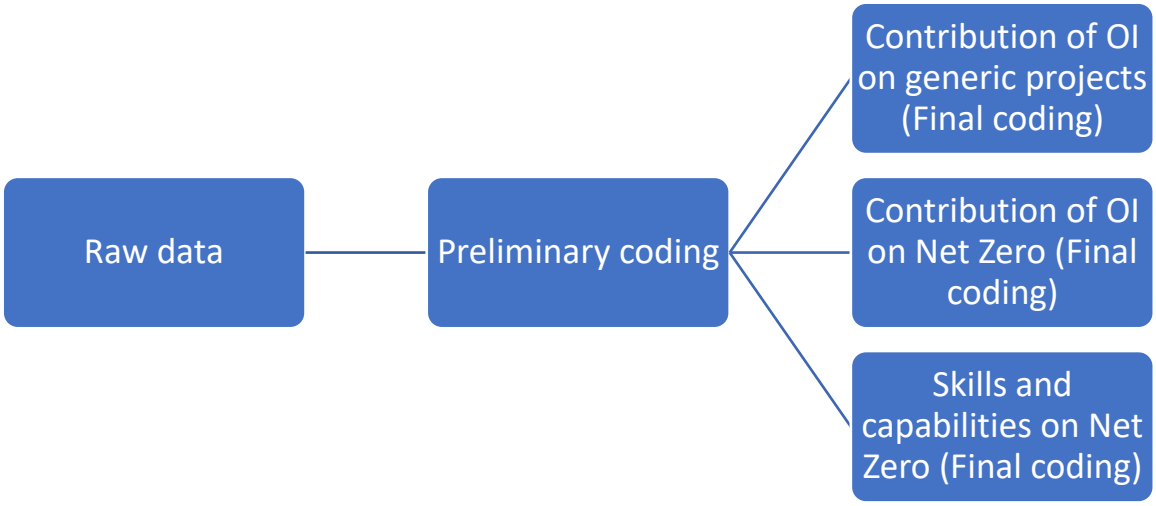

Figure 4-1 Codes structure

5 Findings

5.1. Lists of interviews and codes

Interview	Codes
(Interview 1)	• Knowledge from university about AI algorithms that can provide Net Zero buildings. ○ "**The parent project we have been working on for six years is artificial intelligence for the management of plants** from a thermal point of view. We developed this algorithm using **open innovation tools with two Italian universities**. This algorithm that we are continuing to advance, especially from the point of view of applications, aims precisely at optimizing resources to achieve a zero impact of buildings. Obviously, the algorithm

	alone is not enough, but actions to replace fuels, types of energy supply and so on must also be implemented here." • Incredibly detailed and technical problems related to Net Zero could be solved by startups. • External startup dealing with **digital and organizational competences** to increase internal efficiency and cultural barriers. • Informed about market, about new ideas from external environment, • Know CAGR of external markets. • Knowledge from suppliers, when to stop investment, • 10 times speed compared to internal innovation. • Learn and compare from other ideas. To learn difficult and disruptive theme it's the best. • Collaboration intra corporate. Net Zero challenge is involving every actor of supply chain. Diffusion of disruption through the method of open innovation • Impact on the internal organization, attention is rising on the internal side, also business model are impacted

(Interview 2)	• Knowledge from startups in **biomethane field, to tackle Net Zero problem from an energy transition measure.** ○ "Biometer is a European project that deals with Net Zero, as well as technology to decarbonize transport". • Could be linked to R&D and not opposed to that, leverage on human relationship to increase. Retention of people is an advantage, time spent on formation. Little partners have to express themself and corporate use them as a "defensive weapon" to be on the spot. It's a method to connect the dots • It's an unstructured activity, it's difficult to establish a budget for this activities. • Call for ideas, call for need, internal participation for internal culture, failure culture
(Interview 3)	• Knowledge from startup to tackle digitalization problem in the short run or in the very long run • **Hardware startups have longer time to be developed**, so to tackle Net Zero problems through OI, **digital startups are preferred,** maybe to develop **AI** or digital solutions that are not present in the market

	○ "Startups help us solve small problems such as digitalization, because it is an easily scalable system, not big problems no, big problems if in the long term, probably start-ups can help us develop the systems of the future. It's hard to assume that startups will solve the themes you'll have in 5 years." • It's an open window to CVC. Venture building is present. Cross fertilization with other sectors like mobility (vehicle to grid). To develop big changes, big players must be aligned. Startup could be useful for new competences and smart mind • Short term problems can't be solved by little external players like startup • Innovation hub are present on the field to connect people of the company to innovation • Hackathon as an activity, participation is a key priority.
(Interview 4)	• External knowledge to increase **efficiency in production buildings to increase production quality and efficiency** ○ "Cooperation with companies carrying technological innovation to engage innovation initiatives that have as their objective, as an

	impact, to improve our efficiency by going to reduce emissions of buildings". • Increase customization in projects, so open innovation increase deep tech solution about Net Zero, compared to **standard vendors** • People of the company can participate in creating a new POC with a startup. Efficiency, impact, and quality resolution of company's problems • Internal inertia is present. Accept change is not easy. Innovation is not perceived urgent, but surely important. Other priorities could stop the POC. • Call for ideas. It's a cultural shift for the entire internal population, also operative people can participate to strategy problems. Commitment of top management is fundamental.
(Interview 5)	• Energy transition requires broad competences about the problem to tackle • Geographical connotation is strictly connected to the technology scouted, VC could be dangerous. Net Zero was a STRATEGIC CHANGE IN THE LAST TWO YEARS. They sold the entire old

	business. Augmented awareness. There is not a unique answer for Net Zero, so the multiplication of possibilities of the future. • Could be a flywheel to next investments. • Collaboration with innovation brokers • Culture of startup.
(Interview 6)	• **Blockchain capabilities** based startup used to increase traceability of a product and reduce emissions due to inefficient processes. o "We are cow experts as the vet would say. We are experts in cows, we are experts in agri-food supply chains, we are not experts in the whole part of sustainability. Here we are centered very much easier from startups, where ,how can I give you an example, that concerns a lot of ours and the last contract signed with the one with …, that is for a problem of traceability of the entire supply chain, because we must be certified. Well, beyond the fact, whether we want to use blockchain or not, we should pursue not only animal welfare to keep cows healthy, to monitor everything that makes them feel good, but also to measure sustainability".

	• Startup used to measure impact of POCs that are made in the field of Net Zero. • Circular economy, waste management • Less CH4 emissions • OI can be a facilitator to internal culture of innovation. New roles of sustainability are present, energy manager and sustainability manager. It can catalyze new innovative projects, innovation is a catalyzer of sustainability, but it is not expertise of the company itself. It can be a flywheel to big investments which are not present in this units. • Not used to express need of innovation in the board. In fast moving consumer goods it's difficult to monitor process innovation, normally it's only product innovation. Internal inertia is important to be analyzed. OI could be perceived as a resolution of problems, but doesn't have the budget to be like that • Board members must be committed.
(Interview 7)	• Close innovation is not so effective, external partners are better. Structured process. Covid was a start point. CIO is a good example of this process. Startup is bringing a solution, but also use case of other big

	companies, cross fertilization, CO-innovation intra corporates. Creation of culture of innovation and start of investments. • Alignment of resources is difficult. Internal R&D could be opposed to open innovation process. Business units must have budget to follow POC to scale • Change management is an example. Innovation ambassador are a part.
(Interview 8)	• Paperless • Energy efficiency • Startup to tackle green energy for HQ o "So the building first of all, then there is the whole system and we are also working with a startup to go and recover energy from the sun, but not trivially with the installation of photovoltaic panels." • EV for employees • Startup for CO2 compensation of company's impact • Requalifying parks, planting trees • Open innovation is a strategic lever to solve pains. CV is a tool. More speed if I collaborate with startup obsession, not standard tools, projects

	must be done by very high competences and know how, impact is very strong. Board is committing to this idea of startup, and CVC is gaining interest. • Too many startups, you don't understand which are promising ones. • Culture is important about Net Zero, 680 people involved about sustainability. Concrete approach to culture, be sustainable doesn't have other costs, and it's about bias.
(Interview 9)	• **Cross fertilization of competences on very technical and detailed problems**, like aerospace applied to energy • Sustainable mobility, to cut emissions. • Space economy applied to data and high-resolution image analysis, **that leads to Net Zero avoiding normal operations** o "Satellites have so far been, in my opinion, little used. But on the satellites now they are launching more and more satellites into orbit that have on board technologies that allow you to do a whole series of activities that then must be, can be processed, managed with special software, artificial intelligence and so on, so from satellites for example Eh, first of all on satellites have

	increased in a frightening way in recent years the precision, the resolution of the images. In addition, satellites have included other technologies that are of an exaggerated power with the spectrometric analysis of the soil". • **Spectrometric analysis of soil with SaaS** • Useful to increase the quality of control avoiding helicopter use and increasing the probability of intercepting a gas leakage, which has a GWP much higher than CO2. • Autonomous guide to revolutionize transport. • Apps that can optimize transport mobility, a field in which startups could be interesting • Ancillary services to cover needs in big projects, with new technologies in H2 field. • Open unexpected scenarios, cross fertilization of competences and technologies. Space economy is a broad theme as an example that gives competences to controls of lines. Startup is fast compared to corporate. • Startup doesn't have the same language of corporates. They need to be on the same spot as communication.

(Interview 10)	• Collaboration with customers to eliminate scope 3 emissions • Collaboration with external partners to build an **energy efficient system to cut down losses** and increase efficiency in TSO lines. Capabilities: technical capability to increase o "The use of a gas called SF6. This here we are going to develop solutions, develop solutions internally to remove it, that is, to make our own tests and without gas, or something much more immediate: we are taking solutions from the market". • This knowledge is coming from Old Nasa patent. • Energy efficiency of buildings • Substitution of gases that can have a catastrophic impact on the environment (SF_6) • Procurement based on **circular economy materials.** • Accelerator of startups, emission must be tackled with customers. High vertical competences, research must be used externally. • Call for ideas

(Interview 11)	• Hardware and software competences to build a DAS (distributed acoustic system) to monitor pipelines methane leakages and avoid controls on the lines (scope 1 emissions) ○ "Because you also take away all that part of emissions maybe of the patrol in with helicopter and human patrolling that when I have a vision of the global network. You reduce emissions, we say scope one because basically they are all attributable to direct emissions of a network control". • Spin off of hp, so electronic and software competences that you can't find customizable everywhere. • Co-innovation and network are the most important aspects of OI. • In highly competitive environments OI does not work well • Scale is difficult if you don't have dedicated and allocated budget to be used in innovation. You could also lose innovation because you only to projects to scale and don't see the innovative thing • Vertical competence of startup on a single topic. Technological and competences sold by startup to corporate. Net Zero is a broad theme, so open innovation is necessary. You are fast and lean with this process.

	Niche themes can only be seen by some startup. Startup can customize your product compared to other corporates • In highly competitive sectors it's not the best tool • Failure culture
(Interview 12)	• Net Zero is a matter of survival for large corporates • Incumbents run profitable businesses, Net Zero is not a business necessity, it's a plus • Normally competences are not only energy efficiency, also new technologies, new paradigms • British petroleum invested in low carbon oil.
(Interview 13)	• Material engineering competences to choose the best ne zero carbon materials for a mobile construction site • Electrical competences to substitute high-carbon based vehicles in construction sites • Emissions of vehicles in construction sites are largely caused by vehicles • Strong competences in micro PV systems to enhance efficiency of street lights, through integration

(Interview 14)	• University, lean approach, culture of startup, process is very fast, fast go to market, deep tech is a source of advantage for open innovation practices. • Investments could be not reasonable, and hype of Net Zero could be a limit to the success of the project • Today open innovation is broad, all companies use that instead of R&D, world is too fast and full of ideas that internal innovation is not effective anymore
(Interview 15)	• Robotics, inspection and monitoring of site, automation of goods transportation • Mobility: Oil produced by crops to generate bio fuels • New model of production of the bio fuel, how to develop the supply chain, which is new. • Agri-tech field for new crops • CCUS, energy transition, climate tech technologies. • Parallel process with R&D, also with water neutrality • Difference: startups have a vision of business, big company have a vision on long term process.

	• It's an outlook over long term solutions, like quantum computing, fusion, Open innovation could be the opportunity to know better these technologies • R&D and open innovation will work together to reach the target of Net Zero. They search how to find new green solution, they search for flexibility and MVPs, to scale then. Venture building is the new frontier. BM is very clear for startup. Latest trends monitored. • Ecosystem is very different around the world, you have to adapt to the right one
(Interview 16)	• Hydrogen drones to monitor infrastructure. • Technical capabilities to build a new system that has the technology to be safe, energy efficient and with high payload potential. • Energy efficiency measures to decrease energy requirements from a building, changing secondary electrical system. ○ "We have precisely the secondary data center, which is owned by …, is located in … and had a project to reconfigure the secondary power supply system, coincidentally, there the idea fit perfectly."

	• High vertical competences, solution must be innovative and very distinctive, could find interception of design skills (fuel cell and airship). Expert is not dealing with BM startup yes. Ideas must have acceleration. Connect the points, Startups have BM but not money, create an ecosystem, that can save the planet • Ideas made the difference in the projects undertaken by OPIN. It can be an iterative process, to fail and try
(Interview 17)	• Open innovation is the best tool to decarbonize, no business as usual, new solutions needed, new technologies. • Hydrogen and carbon capture projects • Startups Fuel cell system to decarbonize construction system based on diesel fuels. Targets are scope 3. • Competences on technical and products production, very complex technologies, deep tech technologies. • Network is important, high level for knowing new solution • Second level of network to know if the project could be a failure talking with corporates

	• Business as usual is not reaching targets. New solutions are needed in these businesses. New competences in Net Zero and CCS. Tool to increase competences and integrate them. Product competences in a process approach. Deep tech competences • Reduce risk on new solution based on references
(Interview 18)	• A lot of external sources of innovations come from completely different sectors from the initial one
(Interview 19)	• You can pursue net zero initiatives if internal culture is ready to follow them
(Interview 20)	• To reach Net Zero, big players must undertake projects together and change status-quo

Table 5-1 Summary of codes related to interviews

5.2. Main themes

5.2.1. Contribution of OI on generic projects

Benefits	Limitations
Speed	Limited budget
Effectiveness of innovation process	Internal inertia
Vertical competences	Importance, not urgency
Knowledge (mkt, technology, investments)	Alignment of resources
Spillovers	Relationship with R&D
Internal awareness	Difficulty in highly competitive markets
Network	

Table 5-2 Contribution of OI on generic projects

5.2.2. Contribution of OI on Net Zero/sustainable transition

Benefits	Limitations
• Vertical knowledge • Network • Cross fertilization from sector to another • Internal culture to this theme • Startup has obsession for Net Zero, corporates not • Startup has the speed, corporate no • Decisions on the top, so oi can be implemented by great players	• Choose the right partner in a today buzz word world • To have a result, you have to align resources, but in this field there's a lot of ignorance • Today Net Zero sustainability and SDG are considered synonyms, so OI could have a wrong network value

Table 5-3 Contribution of OI on Net Zero/sustainable transition

5.2.3. Competences and skills on Net Zero

Type of external partner	Sector/field	Type of capabilities/skills	Core capabilities	Secondary capabilities	Product/service sold (if any)	Type of emission tackled	GHG tackled	Net Zero objective	Short description of the project	Reason of choosing this subject
University	AI/Energy efficiency	Technical	Design AI Algorithm	Practice about building efficiency	Research service	Scope 1 emission	CO2	Emission reduction	University consultancy to bring company building to zero emission, through AI algorithm that increase energy efficiency of buildings	Lack of internal competences
External industrial partner	Biomethane/ Biofuels	Technical	Design industrial process to transform biomethane into biofuel	Depuration, transformation and utilization of Biomethane	O&M service	Scope 3 emission	CO2	Emission reduction	Collaboration with external partner to create an industrial process to transform biomethane into biofuels and reduce CFP of company's cars.	Lack of internal competences
Startup	Electrical transmission	Technical	Design of alternative fluid compared to SF6		Patented material/fluid	Scope 1 emission	SF6	Emission reduction	Collaboration with a startup that patented a new material/fluid to substitute SF6 in electrical transmission line, with the same characteristics of isolation and interruption	Integration of internal competences

Table 5-4 Examples of Competences and skills on Net Zero

Source	Source	Type of external partner	Sector/field	Type of capabilities/skills	Core capabilities	Product sold (if any)
Findings	all	Startups	• Energy • IT/digital • Mobility • Construction • Circular economy • CO2 management	Technical, in some cases organizational	Design: • AI/algorithm • Redesign of industrial processes • Materials • Hardware • Aircraft Reporting: • LCA assessment	Smart products O&M service

Table 5-5 Summary of competences and skills on Net Zero

5.3. Contribution of OI on generic projects

The **speed of innovation** as a contribution of OI on generic projects has been one of the most important comments that came from all interviews, especially from (Interview 1) (Interview 7) (Interview 11) (Interview 16), that underlined how innovation made by the tools given by OI is a very fast process compared to normal internal R&D research that has the limitation of getting only internal inputs and is a very slow process that nowadays is not so convenient.

This is well connected with the fact that nowadays world's **challenges like Net Zero must be tackled all together as we were on the same side**, and OI can give the openness and speed to solve big challenges, according to (Interview 1).

Effectiveness of innovation process is a concept stressed by (Interview 11), and is a very important part of OI, which can be an important tool to integrate internal and external competences.

Vertical competences is a concept that was strongly stressed by (Interview 16) that underlined how external partners can give a fundamental complementary contribution to internal competences, giving the necessary vertical competences in the specific field in which the company needs new resources, to tackle a new market or build new technologies.

Knowledge as a contribution of OI to generic projects is a concept that all interviews stressed and remarked, in particular (Interview 1) stressed how it is possible to create a very strong competences basing on the data provided by suppliers, and get a very deep knowledge on a different field from the core business of the company.

Spillover is a concept that was addressed in (Interview 9) where the fundamental opinion was based on the fact that many of the competences and skills scouted by companied using OI tools were taken from very different sectors, so spillovers of knowledge came to be the most important consequence of the adoption of OI practices,

due to the possibility of leveraging on very different sectors, to solve core business problems (ex. Airship competences to decarbonize energy sector)

Internal awareness is a very important concept that came mostly from (Interview 16), where the main aim of the person interviewed was to make understand that the base to create the conditions to use OI tools was to give context and culture to the people involved in the process: creating awareness.

The cultural benefit deriving from OI is a widely spread concept that all interviews stressed, and also (Interview 7) stressed the main aspect connected to internal awareness of people that drove company's change.

Network is surely an important benefit that most of the interviews stressed a lot, in particular (Interview 7) (Interview 16) (Interview 11) that underlined how network intra and inter company can create the positive environment that allows the company to make good financial decisions and reduce the risk of investments connected to a new technology, thanks to spillovers coming from the network.

Main limitations regarding OI applied to generic projects could be resumed in some important concepts coming from interviews.

Limited budget was surely a concept that was deeply stressed by (Interview 11) (Interview 16) which underlined how OI units can't have the necessary power to foster innovation in a lot of contexts, and this could be a problem that can limit the potentialities of internal resources in the field of innovation

Internal inertia was a concept stressed by all interviews, and this is probably the most important limit of OI applied to generic projects: the internal unwillingness to undertake innovative projects or the slowness associated to some internal resources can stop the innovativeness of the company itself (Interview 6).

A very curios concept addressed by (Interview 4) was the existence of importance, but not urgency in the prioritization of innovation, so normally innovative themes in the

company were not prioritized in the right manner and innovation could lose its important role due to other higher prioritized activities.

Alignment of resources is a very strong concept that was discussed in particular in (Interview 6), in which the commitment of top management and other middle resources was considered the most important limitation to OI practices, as it could block the undertake of projects, due to slowness of decision maker or misalignment of resources.

Relationship with R&D is a difficult theme that was tackled in particular in (Interview 15), in which the interviewed told that normally the coexistence of OI and R&D department could create synergies, but in some cases the objective of the two organizational units could be divergent.

A last and very important concept discussed in (Interview 11) was the difficulty of OI in highly competitive markets, and the importance of undertaking OI in the right context, so that the risk of important information leakage should be low.

5.4. Contribution of OI on Net Zero/sustainable transition

In the field of Net Zero, the most important finding that all interviews tried to remark is that OI can give the necessary tools and instruments to embrace big challenges, and some aspects regarding OI applied to Net zero can be stressed with more intensity.

Vertical knowledge is surely one aspect well connected to Net Zero challenges, according to (Interview 11) (Interview 16) (Interview 17), thanks to the possibility of leveraging on external competences on very difficult and niche themes, in which companies can't give a fundamental contribution to change the status-quo.

As said during the (Interview 17) ("Business as usual is not reaching targets. New solutions are needed in this businesses"), the status quo can't be changed in a business as usual mentality, so startups and external collaborations are really necessary to undertake new investments on new technologies in the field of Net Zero.

Network is a concept that in Net Zero is surely stressed, as the decision on investments, risk on investments and difficulty in understanding the technology can be a big barrier, so network inter companies could lower this barrier and allow companies to have a better understanding of what the new clean technology could be and what they can do with this technology. (Interview 18)

Cross fertilization from one sector to another is surely the most important concept stressed by (Interview 9), that highlighted how sectors, that produce completely different technology from the core business of an OI company undertaking OI practices for Net Zero, could be the solver of some important challenges. One example came from (Interview 11), where drones equipped with H2 fueled engine could replace the worse and traditional inspection made with helicopters, that surely could have more impact on an environmental side.

Internal culture is surely an aspect highlighted by (Interview 16) and (Interview 8), upon which company's next decisions could be made: solving Net Zero challenge could be surely a method to make the people of the company know this theme and create culture.

An interesting remark from (Interview 8) underlined how in Net Zero challenges it's important to leverage on external partner's "obsession" for these themes, because CEOs and founders are surely passionate with these themes and developed an obsession to solve a big challenge, so the contribution to Net Zero projects of another company could be more effective.

A good concept emerged also from (Interview 7), in which the concept of speed was marked as the main different and positive contribution of a startup/external partner

compared to the slowness of a corporate/big company, and in Net Zero this could make all the difference.

(Interview 3) remarked a good concept: OI can be the tool to be implemented to solve big challenges like Net Zero, but it could be used only in the case of very big players that decided to undertake synergistic projects and, in this sense, external partners or startups can't have a central role. In this case, the network value creates the conditions to undertake big and synergistic projects between big players and change the status quo.

Some limitations regarding OI practices on net zero relate to the dark side of network value: the knowledge of an environment and ecosystem of actors playing the role of OI on Net Zero could be dramatically negative.

Some partners could have more marketing competences than real Net Zero one, so in this field buzz words and misunderstandings are at base of project failures: some partners are not really competent and Net Zero must be tackled with very strong and vertical competences.

Sustainability, Net Zero, and sustainable transition could be intended, as said in (Interview 8), as synonyms, but unfortunately they are very different concepts, so finding the right partner could be a difficult challenge, if the company wants to undertake concrete actions to change the status quo.

Ignorance about these themes is the main limitation to the undertake of Net Zero projects. (Interview 8)

5.5. Competences/skills scouted by companies in oi in Net Zero

In this field of research, literature review was very poor about the possible competences and skills scouted by OI companies to undertake Net Zero projects, but all findings gave very interesting contributions.

The majority of interviews identified the startup as the main partner with which companies could undertake Net Zero projects, and the main sectors upon which these startup are operating:

- Energy
- IT/digital
- Mobility
- Construction
- Circular economy
- CO2 management

The type of competence identified by majority of interviews is technical and dealing with very strong vertical knowledge (normally founders are ex PhD in their specific field).

To get into more details, main core competences identified in interviews are:

Design:

- AI/algorithm
- Redesign of industrial processes
- Materials
- Hardware
- Aircraft

Reporting:

- LCA assessment

The main products and service sold are O&M services and Smart products.

6 Discussion

For what concern the **contribution of OI on generic projects, literature and findings are almost aligned on the same level**: interviews gave the same results as literature review, where main benefits and limitations of OI were studied, referring to generic projects.

From literature, it's possible to find a **conceptual scheme** through which it's possible to interpret sources and the importance of each term of analysis.

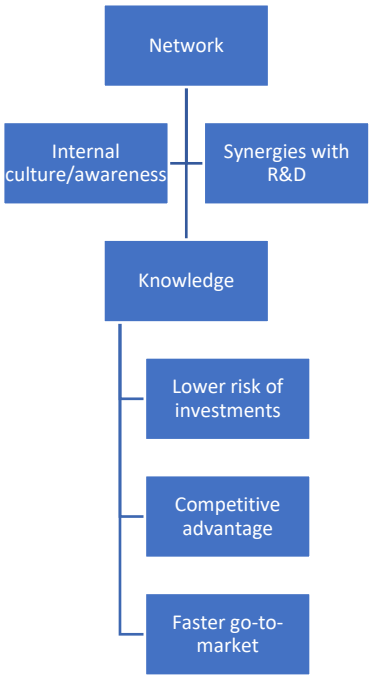

Figure 6-1 Conceptual map about literature review's themes connections

Network inter and intra company is the central point (Tolhurst e Brown 2013) through which companies can create internal culture for innovative themes (Kratzer, Meissner, e Roud 2017) and participation to ideas challenges, and synergies with internal R&D, to create value and better products, thanks to the internal collaboration (Nunes e Abreu 2020).

The most important contribution of network value is the creation of knowledge:

- New ideas
- New technology
- New markets

Knowledge is the base to create the conditions for lower risk investments thanks to the information given by external and internal environment. It's the base to create competitive advantage, seen as the result of internal contribution of resources (RCBV) and external sources of innovation(Nunes e Abreu 2020; Ober 2022; Ullrich e Vladova 2016b).

One of the main benefits encountered in literature review is the faster go-to-market process which gives the possibility to leverage on faster entry of knowledge and get ready for the market in a reduce time span(Zhu et al. 2019).

Findings are almost aligned with these above-mentioned concepts:

Speed of innovation is a recurring item from interviews ("On developing new ideas, business you're very much faster, more or less 10 times faster.") (Interview 1) and deals with the literature concept of faster go-to-market(Zhu et al. 2019), so it's a perfect alignment that finds the same correspondent concept in literature.

One other concept is the **effectiveness of innovation process**, which is a concept that was stressed by interviewed managers ("Companies have understood that open innovation is the ideal answer to their innovation needs and therefore innovate in the old way, therefore within companies, perhaps only within departments. Research and development today is no longer the ideal way and because it is more expensive and much longer along the way and does not necessarily lead to the same results, because often companies do not have all those skills that today are necessary to innovate and therefore instead, opening up outside their company walls and looking at start-ups to other companies, have found their way to arrive in the rapid times that the market requires today") (Interview 7), as a comparison with the close and traditional R&D

approach, which can easily maintain IP, although it can drop the speed and the effectiveness of innovation process (Interview 1). This aspect is really related to the literature concept of competitive advantage, the concrete and factual expression of innovation thought on a single company's strategy.(Lima Rua, Musiello-Neto, e Arias-Oliva 2022)

Vertical competences, spillovers and knowledge are findings'-based concepts that interviewed stressed (Interview 11) (Interview 16) (Interview 17), and must be aligned with the literature general concept of knowledge, that has its main origin in the network value of OI.(Tolhurst e Brown 2013)

Internal awareness was a very important concept in all interviews, and has its confirm in the internal culture concept, stressed in the literature review.

Finally, Network was not so stressed during the interviews, and this is the only difference between findings and literature, that gave much of the OI importance to the network value that generates (in a waterfall process) all the other advantages, for which OI is nowadays widespread among companies.

Main limitations of OI regarding generic projects are deeply discussed in literature and find the same level of importance in findings:

Coordination costs from literature are surely one of the most important aspects of OI limitations(Gentile-Ludecke, Torres de Oliveira, e Paul 2020), and find their same result in findings, where alignment of resources is the main concepts that people tried to stress in the interviews, seen as the main source of failure in innovation projects (" Convince one by one is a very interesting exercise, but it is very difficult because everyone has different barriers and therefore you maybe encounter difficulties in aligning everyone") (Interview 6).

Leakage of important information is a key aspect that literature studied(Su, Mcguckin, e Abhari 2022a), and findings underlined how problematic relationship with R&D and

difficulty in highly competitive markets could lead to a loss of competitive advantage, due to the loss of vital information for the company (Interview 11).

Commitment of top management is an aspect that literature reported as one of the main problems of innovation projects, due to the lack of a strong sponsorship.(Oliveira, Gentile-Lüdecke, e Figueira 2022)

Also findings reported a very curious statement from (Interview 4): "Innovation is considered important, but not urgent", trying to stress how the board is always dealing with innovation as a complementary thing that doesn't have the real urgency of core business activities, so commitment of C-level won't ever be maximum, for this simple reason.

Lack of internal culture could be a problem, according to literature, as not very culturally engaged companies may lack in innovating effectively(Naqshbandi, Kaur, e Ma 2015). This concept was really stressed also in the interviews, where managers underlined how internal inertia led the organization to a constant and problematic slowness in innovation projects. (Interview 6)

Literature studied a concept that interviews didn't tackle: the possibly of losing important internal important competences due to the "make or buy dilemma", in favor of a buy-approach that constantly leads to the outsourcing of competences.(Nunes e Abreu 2020)

Findings, on the other hand, posed the accent on a very practical problem that literature never found**: the constant and problematic lack of adequate budget for OI** units (Interview 11) (Interview 16) (Interview 6). This is a big problem, that normally leads to innovation projects without a clear **scale objective** and POC that are undertaken without a clear scope. Th majority of the budget to implement a concrete innovation is inside BU, but if they don't recognize the value of innovation brough by little-budgeted OI units, it's very difficult to scale a project to all the company (Interview 11).

In this thesis, the most important part was to search for the **contribution of OI on Net Zero, the real research question of the thesis**, and this could be seen as a specific aspect of OI, that is not so well studied in literature. Findings from interviews filled a gap in knowledge about some aspects of OI, regarding Net Zero/sustainable transition.

The approach to analyze this kind of concepts is to understand which are the main above-analyzed aspects that OI **stresses in the field of Net Zero**. The question that thesis is aiming at giving answer is "What is the contribution brought by Open innovation on net-zero?" and both literature and findings give some interesting answers:

Literature stresses the importance of the integration between OI units and R&D departments, as the difficulty and new technologies on the market make companies leverage both on internal and external competences to create a competitive advantage, as capital intensiveness and broadness of investments require deeper evaluations that a single R&D can't give.(Greco, Locatelli, e Lisi 2017)

Lower investment risk and lower risk on innovation are two concepts that are stressed in the field of Net Zero, because to reach Net Zero targets companies have to deal with high-capital-intensive investments and the risk associated with these investments is high, scenarios on energy market is uncertain and bet on the wrong path of technologies could be a failure in financial terms.(Kennedy, Whiteman, e van den Ende 2017)

Network is surely a concept that is very important for literature, mostly in the field of the co-creation of eco-innovations, while in findings network value is considered very important as it lowers the risk associated with the investments on new technology that a similar player has already tested.(Montresor, Ghisetti, e Marzucchi 2013)

Vertical knowledge is a very important concept stressed by both literature and findings(Johanna Ronco, Roberto Pelosi 2013) (Interview 11) (Interview 16), because in

Net Zero external partners must have the competences and skills to give value to the customers, and these competencies are hard to find on the market. They deal with the single market in which OI company operates, but not only:

Another important fact that both literature and findings can tell is the spillover between companies.

Literature is stressing the fact that a company can have spillovers in the same industry to create new more efficient products, like in the case of LIB batteries(Stephan, Anadon, e Hoffmann 2021), but findings are referring to the opposite concept: the interesting fact is that normally, **in the field of Net Zero, companies have spillovers from companies of completely different sectors, and this is creating value for both, because competences needed to decarbonize a sector could be in a completely different sector that doesn't deal necessarily with energy themes**. ("Maybe also apply technical solutions that are used in certain sectors and in another sector that you have never thought of. ") (Interview 3) (Interview 11) (Interview 9)

A negative aspect from literature (Montresor, Ghisetti, e Marzucchi 2013) that is stressed in the case of OI applied to Net Zero is the lack of internal competences for OI companies: what happens is that outsourcing can decrease the ability of a company to leverage on internal competences to solve difficult problems like path to Net Zero: this could lead to a strong dependence on external OI partners, that don't necessarily have the knowledge of the client company's sector to give a good result.

What's more interesting from findings is that **some interesting results can contribute to knowledge in literature**, filling a gap that literature had in this field.

A concept in this field is very important: **internal culture**. It's very important, according to (Interview 16) (Interview 7), to create a culture and promote topics like Net Zero, because normally culture can give the possibility to create new ideas on a difficult theme, and people of the company can contribute to this challenge, providing

ideas related to their single job. This is definitely a very important contribution of OI to Net Zero

Another important concept that (Interview 8) stressed was the concept of the obsession of a startup for its core business: it's important to understand that a startup operating in Net Zero filed is normally obsessed with these topics, so it'll have the capability to solve challenges with effectiveness compared to a normal consultancy company, so OI can give a contribution trying to scout for the right Net Zero solutions on the market, trusting that the partner should have the right "obsession" for these topics.

Another surely important concept given by interviews is the speed of the startup (Interview 1) (Interview 8) (Interview 12), which is significantly higher compared to corporation's speed of innovation, and this is a positive contribution to the effectiveness of innovation projects.

A new topic given by interviews is the very important contribution of OI's network value, which can really give a big change to the entire ecosystem of corporations that deal with Net Zero themes (Interview 17). Decisions about investments and the nature of them are taken by big players on the market, and these decisions must be taken together, as all fields of society deal with Net Zero themes, so the contribution of OI on Net Zero is the possibility to make big players collaborate to undertake together Net Zero projects, that are, as already said, capital intensive and technologically difficult. (Interview 3)

Some negative aspects coming from interviews regarding OI related to Net Zero are the **difficulty of finding the right partner that has the right capabilities to undertake Net Zero projects** (Interview 2). This poses the accent on a very important problem that nowadays this sector is facing trend.

On main aspect that all interviews underlined is the **constant and tragic ignorance about the themes of sustainability, Net Zero, transition**. They are all considered synonyms, but they are not, and this is a big problem, as the decision must be made

with conscious knowledge about these themes: a thing that is not present at all in the market.

Net Zero is dealing with the problem of emissions and sustainability is a broader concept dealing with social and political aspects of society, and these are normally confused and brought to the same level.

Regarding the second research question "What are the capabilities and skills brought by open innovation on Net Zero?" literature and findings are aligned on some aspects:

Literature tells that the main sectors from which an external partner scouted by a OI company on Net Zero are:

- Food
- Energy grid
- Green energy
- Electric transportation
- Mobility solutions

(Hakovirta et al. 2022)

From findings, main sectors from which external partners come from are:

- Energy
- IT/digital
- Mobility
- Construction
- Circular economy
- CO2 management

What is lacking in literature is a deeper understanding of the capabilities and skills scouted in Net Zero field by OI companies, aspects that findings underlined in some relevant skills that literature didn't capture.

What is more interesting from interviews is that **the main capabilities that an OI company must search for are about design and reporting.**

Companies that start to collaborate with OI teams must have some kind of capabilities that are not present internally in the other companies.

Design competencies deal with:

- AI/ algorithms
- Industrial processes
- New materials
- Hardware
- Aircraft

Reporting capabilities normally deal with the LCA assessment, a necessary competence to understand the carbon footprint and the potential of offsetting CO2 emissions.

7 Conclusion and future developments

In this research, important themes regarding Open innovation and Net Zero were discussed, giving some important contribution to existing literature gaps regarding the contribution of OI on Net Zero and competences and skills scouted by companies to undertake Net Zero projects.

Open innovation, the wide spread method for innovating processes and products thanks to the external sources of ideas and knowledge, has a phenomenological relevance and a broad literature background upon which scholars identified different aspects and applications to different sectors(H. W. Chesbrough 2003).

Net zero is a political and social theme, very confused with the broader concept of sustainability, and has its foundation in an empirical relevance, so literature is not very rich in that sense.

The aim of this thesis was to provide answer to some relevant research questions, about the contribution of OI on generic projects and Net Zero, and the skills and competences needed to undertake Net Zero projects in OI companies.

Interviews were conducted to gather relevant data upon these topics, and 20 CIO managers of important Italian companies (mostly listed in Italian stock market) were invited to share their opinions on these themes.

The findings were mostly aligned with literature in the first and generic part related to the application of OI practices in projects of different kinds, but in the intersection between OI and Net Zero, some relevant gaps of literature were filled by answers in the interviews.

The benefits and limitations of OI regarding generic projects were analyzed and confirmed through interviews (New knowledge, ideas, faster go to market, limited

budget of OI units), the contribution of OI on net zero was partially confirmed by findings.

Skills and competences in Net Zero were found mostly in findings, and this is the real contribution of this thesis to literature.

On key aspect emerging from this study is the completely lack of connection between the Net Zero objective of a companies and the provenience of companies undertaking OI projects to reach client Net Zero objectives.

A company operating in a space economy sector could be the net zero partner for another company dealing with oil & gas applications.

A possibility of further research stands in the development of how to measure the environmental impact of OI Net Zero projects. From findings it's clear that financial budget related to OI units in undertaking Net Zero initiatives is very low, so it should be interesting to investigate what could be the impact of each Net Zero project on the environmental performance of the company itself, to give real numbers to a necessary change we will be all devoted to.

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A Appendix A

8.1. Competences and skills on Net Zero

Type of external partner	Sector/field	Type of capabilities/skills	Core capabilities	Secondary capabilities	Service/product sold (if any)	Type of emission tackled	GHG tackled	Net Zero objective	Short description of the project	Reason of choosing this subject
University	AI/Energy efficiency	Technical	Design AI Algorithm	Practice about building efficiency	Research service	Scope 1 emission	CO2	Emission reduction	University consultancy to bring company building to zero emission, through AI algorithm that increase energy efficiency of buildings	Lack of internal competences

External industrial partner	Biomethane/Biofuels	Technical	Design industrial process to transform biomethane into biofuel	Depuration, transformation and utilization of Biomethane	O&M service	Scope 3 emission	CO2	Emission reduction	Collaboration with external partner to create an industrial process to transform biomethane into biofuels and reduce CFP of company's cars.	Lack of internal competences
Startup	Electrical transmission	Technical	Design of alternartive fluid compared to SF6		Patented material/fluid	Scope 1 emission	SF6	Emission reduction	Collaboration with a startup that patented a new material/fluid to substitute SF6 in electrical transmission line, with the same characteristics of isolation and interruption	Integration of internal competences
Startup	Blockchain	Technical and organizational	Design of a private network of blockchain		Private blockchain network	Scope 1 emission	CH4	Emission reduction	Collaboration with a startup to tackle the traceability of the supply chain and decrease CH4 emissions due to an efficient supply chain that used much more resources than needed.	Lack of internal competences
Startup	Solar energy\PV panels	Technical	Design of cost effective and innovative PV panels		PV panels	Scope 1 emission	CO2	Emission reduction	Collaboration with startup that sold adaptable PV panels to generate energy from glass windows of the HQ buildings	Lack of internal competences

Startup	Climate tech	Technical and organizational	Detailed Reporting about CO2 emissions		Report and Carbon Credits	Scope 1 emission	CO2	Emission compensation	Collaboration with a startup to compensate the impact of HQs in terms of emissions, acquiring carbon credits through reforestation activities	Lack of internal competences
Startup	Sustainable mobility	Technical	Design of software	Knowledge about sustainable mobility market	App	Scope 1 emission	CO2	Emission reduction	Collaboration with a startup that help developing booking system for company's sustainable mobility cars.	Lack of internal competences
Startup	Circular economy	Technical	Expertise in circular materials choice		Consultancy	Scope 3 emission	CO2	Emission reduction	Collaboration with external partner and startup to develop circular material based procurement and decrease CFP of materials used in construction sites	Integration of internal competences
Startup	Oil and Gas	Technical	Design of optical fiber DAS system		DAS hardware and software	Scope 1 emission	CH4	Emission reduction	Collaboration with a startup to install a DAS (distributed acoustic system) to monitor pipelines' methane leakages and	Lack of internal competences

								avoid human periodical and visual controls	
Startup	Aviation/Drones	Technical	Design of a customize airship equipped with H2 fuel cell	Airship with equipped software to monitor pipelines	Scope 1 emission	CO2	Emission elimination	Collaboration with a startup to substitute helicopter controls over pipelines with a brand new airship equipped with fuel cell technology	Lack of internal competences
Startup	Construction	Technical	Design of circular materials for construction sites	Construction materials	Scope 2 emission	CO2	Emission reduction	Collaboration with a startup to replace construction materials with new circular materials, that didn't require a production process, so no more emissions	Lack of internal competences
Startup	Solar energy\PV panels	Technical	Design of micro PV	Micro PVs adaptable to street lights	Scope 2 emission	CO2	Emission reduction	Collaboration with a startup to install micro PV panels onto street lights, to decrease energy consumed by them and so emissions related to electricity production	Lack of internal competences
Startup	Sustainable mobility/Agri-tech	Technical	Design of a new production process of bio fuel coming from crops	Consultancy service	Scope 3 emission	CO2	Emission reduction	Collaboration with a startup to produce bio fuels coming from crops and reduce scope 3 emissions (customers)	Lack of internal competences

Startup	Construction	Technical	Design of Fuel cell engine	Fuel cell product	Scope 3 emission	CO2	Emission elimination	Collaboration with a startup to decarbonize construction systems originally based on diesel fuels and substituted with hydrogen fueled fuel cells	Lack of internal competences

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Legenda

Abbreviation	Extended version
OI	Open Innovation
R&D	Research and development
POC	Proof of concept
MVP	Minimum viable product
RCBV	Resource and competences based view
SOI	Sustainable open innovation

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Matteo Lusignani 04/05/2023