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THE EXTENT OF PRIVATE PARTICIPATION IN EUROPEAN MISSION-ORIENTED INNOVATION POLICY: AN EXPLORATORY ANALYSIS OF THE CORDIS DATABASE

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In the loving memory of Shashank

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Acronyms

CORDIS Community Research and Development Information Service i, ii, 4–6, 12–16, 18, 24, 30, 31, 34–39, 41, 42

DARPA Defense Advance Research Project Agency i, 2

FP Framework Programmes for Research and Technological development i, 13, 15

NASA National Aeronautics and Space Administration i

NIH National Institution of Health i, 2

SEDIA Single Electronic Data Interchange Area i, 15

SME Small and Medium enterprises i, 4, 5, 10, 11, 16, 18–20, 24, 27–30, 33, 34, 38, 51

Management Summary

The advent of the 21st century has seen economies worldwide increasingly investing towards developing smart and sustainable innovations for addressing social and environmental challenges such as climate change, adapting to demographic change, public health care an well-being etc. These challenges, often referred to as 'grand challenges' are extremely complex in nature and require dynamic collaborations between the state and private actors to explore and exploit new areas of growth, and develop suitable solutions for the same. Through mission-oriented innovation, policy makers provide a framework for systematically implementing mission-led research to bring together the willing public and private actors to create system-wide transformations across the entire value chain.

By virtue of its abundance of knowledge, skills and resources, the European Union provides a fervent ground for implementing mission-oriented innovation to address grand challenges, but this fragmentation could also make it an extremely complex scenario to do the same. However, through public funds such as the Horizon 2020 framework programme, the public sector can provide a foundation for initiating mission-oriented policies by funding the early, high-risk and uncertain stages of innovation, which private organizations and SMEs can capitalize on to develop smart innovations. In order to do so, the public sector must possess the appropriate set of dynamic capabilities for bringing private actors to actively work towards developing solutions for addressing grand challenges. Additionally, the fragmentation of knowledge and skills available across member nations of the European Union, industrial sectors or technologies differ, making it highly probable that the degree of private participants in mission-oriented innovation also differs.

This thesis identifies the extent of private participation in European mission-oriented innovation by qualitatively analyzing data extracted from the European Commission's Community Research and Development Information Service (CORDIS) database. A descriptive statistical analysis of the data extracted from CORDIS has identified the current degree of private participation in initiatives encompasses in the Horizon 2020 framework programme. This study identifies the proportion of private participation in the various member states of the European Union and across different societal challenges. It also, identifies the participation of SMEs and incumbent in these initiatives. Based on the results obtained, this study discusses its implications for mission-oriented innovation and provides a scope for possible areas for future studies. Additionally, this study goes one step further to analyze the CORDIS database to understand it benefits and shortcomings.

Lastly, this study also provides recommendations for steering policies in a more effective to better suit actors/researchers/policy makers from specific regions or sectors. The results can be utilized by researchers to conduct studies to identify the dependent variables that directly affect the participation of private actors, which can open up areas of research to understand what factors drive the participation of actors in mission-oriented policies. It also provides insights on the possibilities of using the Community Research and Development Information Service (CORDIS) for steering mission-oriented research.

1 Introduction

Governments worldwide have long recognized the potential of innovation to spur economic growth (Solow, 1956). However, it is also essential they realize that the accumulative nature of innovation has a rate as well as a direction (Dosi, 1982). Governments can use the directionality of innovation to achieve broader social, policy and economic goals by utilizing the benefits of research and innovation. As a result, it would be possible to have more sustainable and equitable innovation-led(smart) growth (Mazzucato, 2018b).

The advent of the twenty-first century has seen a rising need to address societal challenges that economies worldwide are facing (Kattel & Mazzucato, 2018). Social and environmental challenges such as climate change, adapting to demographic changes, public well-being and health care (Hicks, 2016; Cagnin et al., 2012) are often referred to as *grand challenges*(Wanzenböck et al., 2020). These grand challenges are 'wicked' in nature (Rittel & Webber, 1973) meaning that they are very complex, systemic and require to be viewed from the perspective of multiple actors spread across various sectors (Edler et al., 2003). For example, resolving the grand challenge of poverty would require interaction between public and private actors from across sectors such as health, infrastructure, education, nutrition, and even a revised tax policy. Therefore, for mission-oriented innovation policy, it is essential to understand the differences between sectors, grand challenges, and concrete problems which these sectors can address in order to resolve the underlying grand challenge(s) (Mazzucato, 2017). By breaking down grand challenges into concrete problems using mission-oriented thinking, it is possible to create new opportunities to spur innovation and research (Mowery, 2010) which can be achieved by melding together production, distribution, and consumption across various sectors such as transportation, health care, energy, food, security and more (Mazzucato, 2017). Simultaneously, missions must also encourage bottom-up experimentation and learning to nurture the innovation process through continuous feedback loops and serendipity (Rodrik et al., 2004)

1.1 Mission-Oriented Innovation Policy

In their study, Kattel and Mazzucato (2018) have stated that Mission-oriented Innovation Policy depends on two key pillars. These pillars include laying down a *"purpose for public investment"* and *"creating conditions for new markets"*, allowing the state to explore new opportunities and simultaneously exploit them to achieve smart growth. Hence, mission-oriented innovation policies are more than just spending money to solve today's grand challenges and addressing them in an organized way.

Mission-oriented policies can be defined as public policies aimed at obtaining well-defined goals by using frontier knowledge (Mazzucato, 2018a) or, as Ergas (2011) puts it, "big science deployed to meet big problems". In this sense, mission-oriented policies focus on solving specific problems that call for "system-wide transformation" across various sectors, requiring collaborations between numerous public and private actors. Although contemporary mission-oriented innovation focus on establishing a strategic direction for addressing social problems, which necessitates selecting "willing" actors to collaborate in multiple bottom-up

projects (Mazzucato, 2018a), it is not the case with missions from the past. The 'Man on the Moon mission' is a perfect example of a typical mission that required dynamic collaborations between actors spread across various high- and low-tech sectors, including materials, communication, electronics, food, security and textiles for achieving desirable results. Unlike previous missions, which were generally formulated in the matter of technological milestones, today's missions are focused on tackling more significant issues that are both technologically and socially complex (R. R. Nelson, 2011; Foray et al., 2012).

The traditional market fixing approach is based on the neoclassical economic theory, which states that competitive markets provide the best outcomes when left to their own devices. It justifies the state's intervention only if there are market failures that emerge in the presence of positive externalities (e.g. basic research, which requires public spending to spur innovation) (Hall et al., 2009; Kerr & Nanda, 2014), negative externalities (e.g. poverty or pollution, which will require levying taxes to the public sector) (Jaffe et al., 2005) and asymmetric information (Hall et al., 2009; Kerr & Nanda, 2014). On the other hand, mission-oriented policies are about fixing existing markets and creating new ones. Therefore, obtaining smart growth within an economy requires moving past the traditional narrative of the state's role merely in identifying and fixing market failures (Mazzucato, 2018a). Mission-oriented innovation policy provides the state with the tools to address such market failures by funding the high-risk and capital-intensive stages of innovation.

The desire to obtain transformation can be seen as the primary intention of mission-oriented organizations such as NASA, Defense Advance Research Project Agency (DARPA) and the National Institution of Health (NIH). It is commonly observed that private organizations tend to shy away from investing in the early stages of research because it is uncertain and risky. Mission-oriented organizations can create new markets and growth opportunities by funding innovation during its early stages (Mazzucato, 2017). For example, the NIH invested approximately $ 30 billion yearly on the research and development of innovative drugs since 2014 (Angell, 2005). Similarly, examples of mission-oriented investments in the European Union include the European Investment Bank's 14.7 billion Euro investment for sustainable cities and the German Development Bank - KfW's investments towards the Energiewende project in Germany (Griffith-Jones & Tyson, 2012). By investing in the early stages of innovation, the state can potentially 'crowd in' private investments by raising expectations of domains with future growth opportunities (Mazzucato & Penna, 2015).

Therefore, contemporary mission-oriented strategies, in which the state takes the lead and private actors follow, differ from traditional ones. The state serves as a market fixer at best. Missions can provide governments with the ability to control the direction of economic growth by strategically investing along the entire innovation chain and generating positive spillovers across multiple sectors (Foray et al., 2012). In a mission-oriented framework that focuses on creating and co-shaping new markets, missions deliver public value by creating transformations in the entire innovation chain. With an entrepreneurial state comprised

of interactions between different public and private actors (Mazzucato, 2018a), these missions can create public value by addressing problems presently relevant to the entire society.

Additionally, in order to enable change during the uncertain stages of innovation and spur economic growth, the state is required to possess a specific set of *dynamic capabilities* (Teece et al., 1997) to bring different public and private actors to work in dynamic partnerships. For creating new markets, the state is suggested to have the capability to engage actors in missions aimed at solving a bigger societal problem (Kattel & Mazzucato, 2018) as creating effective knowledge spillovers requires both a knowledge push and pull(Callon et al., 1991).

1.2 Mission-Oriented Innovation in the European Union

Conceptualizing ways to direct economic growth and the European policy agenda is challenging but necessary, and mission-oriented innovation can effectively bring such a change. Missions can help governments concentrate their research, innovation, and investments on tackling important societal challenges while also generating economic growth, creating new jobs and beneficial spillovers across a wide range of industries.

Within the European Union, member states have different levels of economic development because some of them have invested more/less towards the pillars of innovation – education and research as compared to others (Mazzucato, 2018b). Individual member states are experts in their domains of science and technology (Hidalgo et al., 2007), have different infrastructure and possess distinct capital and material resources. This diversity can pose an obstacle for smart economic growth. However, governments in the European Union can capitalize on the abundant resources and implement mission-oriented policies to formulate solutions for addressing social and environmental issues in Europe (Mazzucato, 2018b).

In the past few decades, top-down experiments and expert authority in the governance of science and innovation has decreased, while there has been a simultaneous increase in the involvement of new stakeholders from the general public (Stilgoe et al., 2013; Irwin, 2006; Hajer, 2010). Through public funding initiatives such as the Horizon 2020 framework programme, the public sector might involve more private organizations and start-ups in creating new markets and hence generate greater spillovers across different sectors. Missions give policymakers a clearer view of the elements necessary to bring about change. Hence, it provides a way to consolidate the results from different actors for solving a problem relevant across the European Union (Mazzucato, 2018b).

1.3 Problem Statement

Presently, mission-oriented policies provide a framework for the state to effectively take the lead in spurring innovation and creating new opportunities for private actors to exploit. The state can benefit from the activities of private actors and formulate solutions for solving the greater societal challenges that economies worldwide face today. This introduces the central notion in the literature on mission-oriented innovation policy, which points to the need for the industry's involvement in public research to create spillovers,

allow for valorizations, and enhance a nation's ambidexterity. by taking the lead in spurring mission-led research, i.e. *exploring* new areas/domains of growth, the state can open up the ground for private actors to commercialize i.e.*(exploit)* these innovations and collaborate towards addressing the greater societal challenges faced by society.

Additionally, member states of the European Union are very fragmented, meaning that they vastly differ in their expertise, possess different sets of resources and capabilities. This diversity within the European Union makes it a more complex platform to implement mission-oriented policy. However, by exploiting the array of resources and skills available, governments can strategically create new opportunities for private businesses to capitalize on while simultaneously addressing the societal challenges faced in the scale of the entire European Union.

Therefore, the industry's engagement in mission-oriented research is crucial in a nation's response to societal challenges. However, the extent to which private organizations are involved in mission-driven public research in the European Union remains unclear. Neither is it clear to what extent the participation of private organizations varies across different nations and in initiatives aimed at specific societal challenges. In addition, there is increasingly more awareness of what roles specific firm types (i.e., incumbents and SMEs) take on in system-wide transformations. Hence, it would be interesting to identify the types of private organizations that engage in contemporary mission-oriented innovation policy.

1.4 Research Objective

The objective of this thesis is to identify the extent of private participation in European mission-oriented innovation.

Amidst the growing need for responding to societal and environmental problems such as climate change, depletion of resources, public well-being and health care (Mazzucato, 2018a), economies worldwide are looking for innovation-led growth that will contribute to solving these problems on a global scale. The diversity of resources and skills in its member states makes Europe a fervent ground for mission-oriented innovation. Additionally, the literature states that addressing grand challenges requires dynamic collaborations between public and private actors. They can utilize the available knowledge and other resources to develop desirable solutions. Therefore, the central objective of this study is to identify the extent of private participation in European mission-oriented initiatives.

In order to address the research objective, data regarding mission-oriented initiatives within the European Union is exported from the CORDIS database (*CORDIS | European Commission*, n.d.). This extract is used as the central database for this research. In section 3.1.2, the contents of the CORDIS export are explained in greater detail. Additionally, this thesis will further examine the contents of the data extracted in order to identify any shortcoming. Thus, a secondary research objective is to interpret any discrepancies in the CORDIS data and provide suitable suggestions for enhancements (in terms of available data) to the same.

1.4.1 Research and Sub-research Questions

In order to fulfill the research objective of this thesis, it is necessary to formulate and answer the research question. A more detailed understanding of the research objective can be obtained by further breaking them down into multiple sub-research questions. Therefore, the first research objective is translated into the main research question:

- **'What is the extent of private participation in European mission-oriented innovation policies?'**.

The main research question is elaborated further in terms of three sub research questions. Member states in the European Union differ in their institutional backgrounds, possess different types of infrastructure, human capital, proprietary skills etc.(Freeman, 1987; Lundvall, 1992; R. Nelson, 1993). Thus, it is highly likely that the proportion of private organizations participating in mission-oriented projects in individual European member nations also varies. This leads to the following sub-research question:

- *What is the proportion of private participation in mission-oriented projects in different European nations?*

The data extracted from CORDIS includes eight societal challenges defined in the database, and there are several mission-oriented initiatives actively carried out focusing on each of these challenges. Addressing the societal challenges requires actors from various sectors such as health, energy, transportation, security to collaborate. These sectors also differ in their very dynamics, that tangible and intangible resources they contain and skills possessed (Pavitt, 1984). As a result, it is possible that the extent of private organizations in mission-oriented research would also vary, and this introduces the second researcher question:

- *What is the proportion of private participation in mission-oriented projects in various societal challenges?*

The early phases of innovation are highly uncertain and risky. Thus, private organizations are often hesitant to invest in basic research (Mazzucato, 2017). This is attributed to the fact that investing in new technologies could lead to the creative destruction of the incumbent's existing proprietary competencies to meet the demands of the new technological paradigm. As a result, incumbents mainly seek to improve their market position and competencies by making incremental adjustments to their existing technologies (Smink et al., 2015). On the other hand, SMEs and start-ups have greater flexibility when it comes to spending and innovating in fundamental research to develop new technologies. Furthermore, achieving technological transformation necessitates a better understanding of the relationship between incumbent and new technologies (Hekkert et al., 2007; Hockerts & Wüstenhagen, 2010). As a result, incumbents and SMEs must collaborate to address the greater contemporary societal challenges faced globally. Hence, the last two sub-research questions are:

- *What is the proportion of SMEs in mission-oriented projects in different European nations?*
- *What is the proportion of SMEs in mission-oriented projects in various societal challenges?*

As mentioned above, this study aims to address the main research objective through an analysis of the data extracted from the CORDIS database. By doing so, it is possible to examine in more detail regarding what data is available in the CORDIS export. Additionally, it will also provide insights into any shortcomings of the data extract and open up discussions regarding what additional data would be valuable for research and innovation, if recorded and maintained in this database. Therefore, to address the secondary research objective as discussed in section 1.4 above, this study will aim to answer an additional research question as follows;

- *What are the opportunities and challenges when using the CORDIS database for gaining insights on European mission-oriented research?*

2 Theoretical Background

2.1 Dynamic Capabilities of the Public sector

In the 21st century, many innovation policies are directed towards addressing societal challenges faced by countries all over the globe. These societal challenges are usually *wicked problems*, which makes them very systemic and complex (Rittel & Webber, 1973). Solving this so-called *grand challenges* is, therefore, not straightforward and requires public and private actors to work in dynamic partnerships. However, this requires moving past the narrative that the public sector serves only in fixing markets and not in creating new ones (Kattel & Mazzucato, 2018).

Exploration activities are much less certain when compared with exploitation. Their outcomes are more distant in the future and hence, are further away from the locus of adaptation. Activities that are good in the long run may not yield the best results in a short period. Additionally, numerous beneficial activities for one organization may not help in the development and growth of another organization. Basic research yields fewer definite results, take significantly longer than the commercialization of products/services (exploitation) and are very risky (March, 1991).

In order to address societal challenges (such as climate change, improving public health and well-being, adapting to demographic changes) that are faced by nations worldwide, private organizations will have to step out of their comfort zone to explore new markets. Private businesses usually focus on building their existing competencies by bringing incremental changes to their products/services, commercializing them and generating profits to gain a stronger hold of their existing markets. However, even the largest of organizations learn how to allocate their resources between exploration and exploitation activities only through years of experience, and hence, they tend to shy away from exploring new markets (March, 1991).

In the context of mission-oriented policies aimed at resolving more significant societal problems in the present day, the public sector must possess the ability to initiate basic research and explore smart and sustainable ventures in innovation and simultaneously open up the new markets for private actors to exploit. Private firms possess the *dynamic capabilities* to combine, build and restructure their existing competencies and resources in order to adjust according to the uncertain and changing environment of the market (Teece et al., 1997; Karo & Kattel, 2018). Similarly, the state requires a specific set of dynamic capabilities to allow for mission-led exploration and exploitation.

For creating new markets through mission-oriented policies, the public sector must possess a specific set of dynamic capabilities. These capabilities are also crucial in order to develop an entrepreneurial state (Rodrik, 2011; Mazzucato, 2013). They must have the ability to bring various private organizations to participate in bottom-up missions and simultaneously allow these organizations to exploit the new areas of growth. The public sector should not 'bow down' to private organizations that seek incentives like tax cuts (Mazzucato, 2013); instead, they can reap benefits from the efforts of the private firms in the from taxes in order to fund future opportunities. The public sector is not only responsible for facilitating economic growth but is also an important actor that takes risks to initiate innovation (Mazzucato, 2013). Hence, they must also have the

ability to develop rational policy instruments and provide public funding directed to achieve the goal of missions-oriented innovation policies (Kattel & Mazzucato, 2018).
Addressing the more significant societal challenges such as climate change, adapting to demographic changes, shortage of resources, public well-being, and health care faced by nations today cannot be executed by the public sector's efforts alone. The public and private sectors must collaborate to explore new areas of growth that they can exploit to create smart innovations for resolving the grand challenges faced today. However, it is not known to what extent private organizations currently participate in European mission-oriented policies and hence, it would be helpful to identify the same.

2.2 Private participation differences between nations

The complex nature of 'grand challenges' requires an evaluation from multiple actors spread in different nations/geographical regions. A few studies regarding new knowledge creation has pointed out that scientific knowledge is not restricted to a particular location under the belief that codified knowledge can be easily transferred across regions or nations using the internet, conferences and scientific journals (David & Foray, 2001). On the contrary, various theorists have claimed that the world is spiky(Florida, 2005; McCann, 2008; Storper, 1992), meaning that different nations cannot excel at every field. This supports the fact that tacit knowledge is irregularly scattered in different nations. Existing studies have factually shown that a majority of the world's top researchers and scientists are located in relative smaller areas in countries within the European Union and the United States of America (UNESCO, 2010).
Tacit knowledge it is not easily transferable over larger distances (Gertler, 2003; Bathelt et al., 2004) and requires geographical and institutional proximity to be easily transferable (Boschma, 2005; Polanyi, 1996). As a result, its knowledge often tends to pile up in a confined space/region (Heimeriks & Boschma, 2014). Because knowledge is tacit and collective, it also tends to be specific to actors within that region and cannot be easily imitated (Heimeriks & Boschma, 2014). Cohen and Levinthal have also stated that it is easier for organizations and scientists to learn and make use of knowledge that is in their proximity. This is the reason why organizations and researchers located in different locations build a different set of cognitive abilities in time (R. R. Nelson & Winter, 1982). Hence, we can say that knowledge is not only path-dependent but also *place-dependent*, and it is possibly the reason why actors located in different regions tend to specialize in specific activities (Heimeriks & Boschma, 2014; Heimeriks & Balland, 2016). Knowledge production is also dynamic (Heimeriks & Balland, 2016), which means that the branching creates new knowledge/innovation out of existing skills and knowledge (Schumpeter, 1934).
Moreover, nations also differ in the human capital that they possess. Human capital is defined as the knowledge, skill sets and habits possessed by personnel (Goldin, 2016) directed at activities that are aimed at generating well-being for the society (Becker, 1962). By investing resources towards developing human capital through activities such as education, job training and health care, nations can develop a smarter and more sustainable future. Nations where labour receives higher wages and physical inputs tend to have

more human capital than poorer nations (Becker, 1962). As a result, the differences in human capital across nations also affects the creation of new knowledge.

A national innovation system is made up of actors spread across sectors like government, industries and universities. (Godin, 2009) primarily focus on dynamically learning and creating new knowledge for producing desirable innovations and creating new domains for future growth Lundvall. However, nations have unique cultural and political backgrounds, possess expertise in different sectors, have different resources, human capital and infrastructure (Lundvall, 2010; Godin, 2009). In the context of the European Union, researchers like Mazzucato have pointed out that the member states cannot individually address grand challenges like climate change, public well-being or depletion of resources. Due to the difference in their institutional background and fields of expertise. Based on these contributions, it has thus become apparent that the very dynamics of innovation differ substantially between nations.

2.3 Private participation differences between sectors

Many theorists across the globe have pointed out the importance of production, adoption and diffusion of new technological innovations for the development of an economy. These factors are also crucial for the social and economic growth of a nation (Soete, 1981). However, the advancement of technology in the past has been unequal in different sectors. Sectors that displayed slow growth of productivity have experienced an increase in the relative costs, which has led to a drop in the performance of sectors such as housing, service industries and governmental sectors like garbage collection etc. On the other hand, sectors with more tremendous technological and productivity growth experienced a surplus of capital and resources (R. R. Nelson & Winter, 1977). Additionally, studies by many researchers have indicated that dissimilarities in productivity growth have led to an imbalance in the technological and social development of different sectors in various countries all over the world (Kendrick, 1961; Ruttan & Salter, 1961; Schmookler, 1952). As mentioned in the previous section, every member state in the European Union has a different institutional background. The member states also specialize in different sectors (Hidalgo et al., 2007) like health care, transportation, energy, food etc. For the success of missions to resolve more significant societal challenges faced by countries globally, there must be a collaboration between actors from different sectors. Studies have pointed out that the very actors, institutions, infrastructure and the dynamics of technological development and innovation differ in different sectors (Pavitt, 1984). Therefore, it can be assumed that the participation of private organizations might also differ between sectors.

2.4 Private participation differences between technologies

Existing innovation policies and innovation systems are often only suitable for aiding existing technologies and are not as effective in supporting new and emerging technologies (Archibugi & Lundvall, 2001). This is because the knowledge and resources required to develop new technologies are rarely ever implanted in the infrastructure of a single region, country or sector(Hekkert et al., 2007). With the growing need for

sustainable and smart innovation, it is necessary to take a different approach to develop technologies that can be used to address current societal problems.

A technological innovation system can be defined as the amalgamation of several different actors within the same institutional background that collaborate in order to develop, diffuse and use a new technology (Carlsson & Stankiewicz, 1991). The actors involved in the process are spread across inter-linked sectors and firms. Technological Innovation systems comprise various technologies with different applications. Technologies like 5G, bio-materials, nanotechnology etc., stand at different stages in their development, and these stages determine the extent to which innovations are commercialized (Kline & Rosenberg, 1986). However, actors may perceive the knowledge available for the development of new technologies differently because they tend to use the knowledge that is readily available within their technological environment (Dosi, 1982; Mcloughlin et al., 2000). Hence, the maturity level and unique dynamics of technological innovation systems hint that the participation of private organizations in public research might differ between technologies.

2.5 System transformations: Participation of incumbents and SMEs

Currently, firms have realized that there is an increasing need for smart and sustainable innovation for addressing societal and environmental challenges (Hockerts & Wüstenhagen, 2010). However, innovations that bring about change and disrupt markets are often radical and can have unfavourable effects on the interest and growth of businesses (Smink et al., 2015). Large incumbents usually have the material and financial resources to build on their existing competencies to develop such innovations. However, they tend to stick with their institutional strategies and strengthen their market position by investing in existing activities (Smink et al., 2015).

Emerging technological paradigms can result in the creative destruction of the markets (Schumpeter, 1934). They can facilitate a window of opportunity for startups and SMEs to chase new opportunities without having to rely on any existing financial and material resources (Tushman & Anderson, 1986; J. Utterback, 1994). A change in the technological paradigms can also be distinguished by the extent to which startups and SMEs are developing new innovative products (Metcalfe & S, 1994; J. M. Utterback & Suárez, 1993). Additionally, Hockerts and Wüstenhagen has also stated that it is usually startups and SMEs that spur such disruptive and sustainable innovations. It is the success of startups and SMEs that pushes larger incumbents to invest their resources into new technology and perfect the innovations for the market (Hockerts & Wüstenhagen, 2010). Thus, startups and SMEs play a crucial role in initiating the development of innovations and system-wide transformations and therefore, analyzing the extent of their participation in European mission-oriented innovation would be of value.

As mentioned above, it is commonly observed that private organizations tend to shy away from investing during the early stages of innovation because it is uncertain and risky (Mazzucato, 2017). This is mainly because investing in innovations causes creative destruction of the incumbent's existing competencies in order to fit the requirements of the new technological paradigm. Hence, incumbents tend to strengthen their

market position and build on their competencies by making minor incremental changes to their existing technologies(Smink et al., 2015). On the other hand, SMEs and startups are more flexible with investing and innovating in basic research for developing new technology. Additionally, realizing technological change requires a clearer perception of the link between incumbent technology and emerging technology(Hekkert et al., 2007; Hockerts & Wüstenhagen, 2010). Hence, it is equally important that both incumbents and SMEs/start-ups innovate together to address current societal problems. However, it is currently unclear as to how many incumbents and SMEs engage in the innovation of new technologies. Thus, it would be interesting to analyze the extent to which incumbents and SMEs/startups that are participating in mission-oriented innovation encompassed in the Horizon 2020 framework programme.

3 Research Methodology

As mentioned previously in section 1.4, the central aim of this thesis study is to identify the extent of participation of private organizations in European mission-oriented innovation policies. For this purpose, a quantitative research methodology is implemented in order to uncover patterns and causal relationships within the population. Additionally, quantitative research methods factually obtain more reliable and generalizable results than qualitative studies (Yin, 2017). By quantitatively analyzing the CORDIS database, it would be possible to gain a better understanding of the extent of private participation is European mission-oriented innovation policy. A descriptive statistical analysis is carried out on the CORDIS database to obtain scientifically valid and conclusive results to answer the main research question. The research is a study of archival data of information on mission-oriented initiatives exported from CORDIS. For addressing the research objective, the data has to be analyzed by means of instruments that will help in better understanding the implications derived from it. As this thesis uses archival data, Microsoft Excel is used to manipulate the data to fit the requirements of the research objective. Additionally, Python programming language is used as a tool for visualizing the data. In order to fit the data extracted from CORDIS as per the aforementioned research objective, it has to be systematically reduced to obtain a suitable sample. The steps used to obtain this sample are discussed in section 3.2.2. The CORDIS database and its contents will be discussed in more detail in section 3.1.

Drawing back from theory, it is understood that contemporary mission-oriented projects are focused on resolving grand challenges such as climate change, adjusting to demographic changes, public well-being and health care etc. For the scope of this thesis, the projects selected for data analysis are also aimed to address these very challenges faced within the European Union. This research will analyze mission-oriented projects under the Horizon 2020 framework programme within the European Union. However, these steps can be reused to yield results for mission-oriented initiatives conducted in different countries conducting mission-oriented research funded by the Horizon 2020 framework programme. Although governments across the globe may fund mission-oriented projects differently, mission dynamics differ per nation, societal challenge, industrial sectors or technology.

3.1 Research Design

This section discusses the research methods that were utilized to analyze the data obtained to answer the research objectives systematically. It contains a detailed description of the steps that are followed to reduce the data, obtain the population and samples, and finally to visualize the results(in the form of box plots) for analyzing the extent of private participation in European mission-oriented innovation policy. The following subsection introduces the Horizon 2020 framework programme. Horizon 2020 is often used by authors studying mission-oriented innovation as a base ground for quantitative analysis in this field, mainly because it serves as an essential catalyst for spurring mission-oriented innovation all over the globe.

3.1.1 Horizon 2020 Framework Programme

Mazzucato (2018) is one of the pioneering researchers on the topic of mission-oriented innovation policy within the European Union. Her studies have often pointed out the benefits of implementing mission-oriented research within the European Union by addressing the abundance of tangible and intangible resources within this region. From the literature study in section 2, it is also understood that the Horizon 2020 framework programme can be seen as a starting ground for funding mission-oriented initiatives in the European Union for addressing societal challenges faced across this region.

The Horizon 2020 framework programme is the central financial instrument for implementing the Innovation Union, i.e. the major Europe 2020 initiative for ensuring the European Unions competence in innovations when compared worldwide. It is one of the world's largest global funds for the field of science and innovation, including research in frontier science and providing monetary aids to start-ups. For example, the Horizon 2020 has funded approximately €80 billion between 2014 and 2020 for scientific research within the European Union. The Horizon 2020 framework programme can be seen as an instrument to steer economic growth and create more opportunities for individuals. Through continued support from the political leaders and the European parliament, the programme focuses on addressing the more significant societal challenges faced by nations worldwide by creating smart and sustainable economic growth. With its focus on various types of social and environmental challenges such as industrial leadership, societal issues and excellent sciences, the Horizon 2020 programme embodies one of the largest mission-oriented public funds. It covers numerous initiatives that are focused on research related to addressing societal challenges within the European Union. By doing so, the Horizon 2020 framework programme aims to generate exceptional and breakthrough scientific research to eliminate barriers to collaborations between public and private actors. As mentioned above, through continuous funding and investments in basic research, the public sector can attract more private businesses to contribute towards creating breakthrough innovations for the betterment of society (*What is Horizon 2020? | Horizon 2020*, n.d.).

Therefore, as this thesis mainly focuses on identifying the extent of private participation in European mission-oriented policy, an initiative funded by the Horizon 2020 framework programme will be observed and analyzed through a descriptive statistical methodology to answer the main research objective.

3.1.2 CORDIS Database

It is previously mentioned in section 1.4 that data on mission-oriented initiatives conducted within the European Union are extracted from the CORDIS database. The Community Research and Development Information Service(CORDIS) is a database that stores results, facts and figures about projects that are funded by various European framework programmes such as the Framework Programmes for Research and Technological development (FP)(including FP1 through FP7 and others) as well as the Horizon 2020 framework programme. CORDIS is a vast and well structured public repository that contains detailed information regarding the European Commission's mission-oriented initiatives that are conducted within Europe. It includes reports, fact sheets, details regarding the participants and links for individual initiatives that are openly available for public use. Additionally, there are numerous reports and publications that

CORDIS produces independently, which are also available for open-access use. The web pages can be navigated in six different languages, including English, German, Spanish, French, Italian and Polish (*CORDIS | European Commission*, n.d.). However, the data available on the CORDIS database web page is available for download only in English.

On behalf of the European Commission's research and innovation Directorates-General, CORDIS is operated by the Publications Office of the European Union and other public agencies with support from specialists for editorial, technical and data analysis purposes. Their main goal is to make the results of scientific research conducted within the European Union readily available to scientists and researchers, who can explore and exploit the knowledge for generating disruptive and sustainable technologies/services to foster smart innovation-led growth within the Union. CORDIS is a crucial instrument within the strategies of the European Commission to exploit the results of scientific research and is also managed and funded by the Horizon 2020 framework programme (*CORDIS | European Commission*, n.d.).

Although the CORDIS database contains the necessary information on initiatives funded by various framework funding programmes mentioned previously, this thesis only focuses on projects encompassed in the Horizon 2020 framework programme. Additionally, only data that is provided in English is extracted from CORDIS. Lastly, the database also contains initiatives that are being carried out globally. However, this thesis will only observe and analyze mission-oriented initiatives that are conducted within the European Union. In this thesis, cross-sectional research will be carried out on the data regarding a plethora of mission-oriented projects that span across national borders and are conducted over a span of eight years. The relevant data is collected from the CORDIS database (*CORDIS | European Commission*, n.d.).

3.1.3 Data collection

The previous section provides a detailed overview regarding the Horizon 2020 framework programme. It highlights the selection criteria behind why it is selected as a reference for identifying the extent of private participation within the European Union. Additionally, section 3.1.2 highlights the nuances of the CORDIS database, its contents and similarly highlights the selection criteria behind using CORDIS as the central data source for this thesis.

In order to derive scientifically valid and reliable observations regarding private participation in European mission-oriented policies, relevant data was exported from the CORDIS web page. This web page can be approached via the links provided below. Additionally, some critical steps used to extract the data are recorded below to make the results of this thesis easily retractable. The following list includes important web pages that were referred to for this thesis.

- To derive solutions for the primary objective of this thesis, the European Commission's CORDIS database is selected as the central data source. The web page for CORDIS can be accessed via the link - *https://cordis.europa.eu/*

- For this thesis, the data is extracted in English. However, data in the web pages can be viewed in five other languages, which are mentioned in section 3.1.2, but the database is only available in English.

- The central web page that contains data regarding projects within the Horizon 2020 framework programme are accessible via the Single Electronic Data Interchange Area (SEDIA) web page. This can be accessed via the link *https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard*

- The CORDIS database web page can be accessed via the link *https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/c616ed33-064c-40c0-803a-e75045b78c05/state/analysis* . The visible data-sheet can be extracted by right-clicking on the sheet. By selecting the option 'Export', the data is renamed and saved as 'CORDIS-Extract'. This data is the raw extract, which has to be selectively reduced to obtain the population.

The aforementioned links can be utilized to extract the raw data from CORDIS. Having completed these steps, the CORDIS database that is used for addressing the first primary research objective is obtained. Detailed snapshots of the steps followed to reach the CORDIS database web page are added in the Appendix A for further reference. The data is extracted in the form of a Microsoft Excel spreadsheet by right-clicking on the table and selecting *Export*. The downloaded file is renamed and saved as *CORDIS-Export*.
The raw data that is exported from CORDIS contains facts, figures, details regarding participants related to a large number of initiatives, many of which are not relevant for the purpose of this thesis. For this reason, it is essential that the data extracted is reduced by selectively excluding fields that do not directly affect the outcome of the research. Next, the steps used for selectively reducing the CORDIS are explained in brief.
The raw CORDIS database comprises mission-oriented initiatives that are encompassed in framework programmes, including the FP (FP1 to FP7), Horizon 2020 and others as mentioned in section 3.1.1. It also contains details of numerous initiatives that have already been implemented or are being conducted in nations all over the globe. Considering the focus of this thesis, the data has to be controlled to obtain the population out of which samples can be extracted for answering the individual sub-research questions. That extracted data set is displayed using MS Excel spreadsheets. In total, the data contains 34 individual columns. Most importantly, the columns that have been compared and analyzed for this thesis include;

- **Column E - Project Number**: Contains the project number issued by the authorities. By comparing the *Count of Project Number* with the type of organization, several different types of actors per mission-oriented project can be identified. It will also highlight those projects that have private participation and those which do not.

- **Column G - Project Acronym**: Contains an abbreviation of the project title (which is also populated in the data in column H).

- **Column O - Legal Entity Type Description**: Contains details regarding the type of organization. This field is used to identify the number of private actors. Upon comparing this field with the project title, it is possible to identify which all mission-oriented projects have private organizations participating.
- **Column T - Country**: Describes the country in which the project is being conducted.
- **Column Z - Thematic Priority Abbreviation**: Contains an abbreviation of the Thematic Priority Description. The term Thematic priority is used to describe the type of societal challenge that the corresponding project aims to address.
- **Column AB - SME Flag**: Contains the details of whether an organization participating in the corresponding mission-oriented projects is and SME or not. It is indicated in the Column as Yes or No.
- **Column AD - Project End Date**: Contains the date on which the project was completed or is expected to be completed.
- **Column AF - Pillar Description**: Contains a description of the type of grand challenge that the project aims to address.

Although archival data regarding projects encompassed in the Horizon 2020 framework programme is readily available in the CORDIS database, it has to be systematically controlled to obtain the reduced dataset to fit the scope of this thesis. This reduced data forms the population which is used for data analysis.
To obtain the population from the raw CORDIS database, the file is opened as a Microsoft Excel spreadsheet. This allows for easy manipulation of the raw data, which can be sorted and reduced systematically. The first row in this sheet contains the headers, i.e. a description of what data is populated in each column. By applying filters to the first row (headers) of all 34 columns, each column is sorted to include only the necessary data that fits the scope of this thesis, and irrelevant data is excluded from the spreadsheet. The following listed steps were used to sort and reduce the CORDIS extract;

- **Column T - Country**: This thesis primarily focuses on mission-oriented innovation policy that is being conducted within the European Union. For this reason, only the European member states that are available in the CORDIS database are selected. Therefore, the population contains a total of 28 European countries, which include Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Turkey and the United Kingdom. All the remaining data in this column is deleted and excluded from further research.
- **Column AD - Project End Date**: This thesis aims to identify the extent of private actors participation in European mission-oriented projects. Therefore, it would be beneficial to look at projects that will be completed in the near future as these projects will be the most inclusive in terms of actor and actor types. Therefore, only those projects that were completed or are expected to be

completed by 2022 are selected for the study. Thus, the final population includes projects that are conducted and completed/to be completed between 2014 and 2022. Projects the have end dates further in the future(2023 and ahead) are excluded from this study.

- **Column AF – Pillar Description**: The column 'Pillar Description' describes the type of grand challenge that the corresponding initiative aims to address. As previously mentioned in section 3.1.1, the Horizon 2020 framework programme encompasses initiatives that address various types of grand challenges. This column includes grand challenges such as *'Cross-theme' challenges*, *'Excellent Sciences'*, *'Industrial Leadership'*, *'Science with and for society'* and *'Societal Challenges'*. This study is focused on identifying private participation in mission-oriented innovation that is directed towards resolving grand challenges. Therefore, only Societal Challenges are selected in this column, while the remaining data is excluded from the population.

Having controlled the data in each of the three columns mentioned above and excluding all data that is not relevant for this research, we obtain the population for this thesis. The population is maintained in a new Excel spreadsheet, namely 'Final Lists Proportion'. In total, this contains 5024 individual mission-oriented initiatives aimed at addressing societal challenges. These initiatives are all conducted between 2014 and 2022 and span across the 28 recognized member states of the European Union. This population can be used to derive samples for answering the sub-research questions of the first primary research question. In the next section, the data is analyzed and prepared for visualization, which can be used to derive results that contribute to the literature.

3.1.4 Data Sampling Strategies

The first sub-research question (see 1.4.1) aims to identify the extent of private participation in mission-oriented innovation across different European member states. The population contains 28 member nations in total. However, not all the member nations are inclusive enough in mission-oriented innovation funded by the Horizon 2020 framework programme, and hence, contain very few projects with private participants. Including this data in the research will obtain inconclusive results, which may not be enough to address the main research question. For this reason, a sample containing the top 12 economies in the European Union is selected. These top 12 economies include Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden, Turkey and the United Kingdom. Russia is considered as a part of the top 12 economies in Europe, but it is excluded from this thesis as it is not recognized by the European Commission as a part of the European Union.

The second sub-research question (see 1.4) aims to identify the extent of private participation in mission-oriented innovation for addressing various types of societal challenges. As mentioned above (see 3.2.2), the column Thematic Priority Abbreviation contains the abbreviated description of the type of societal challenge. In total, there are eight different challenges, which make up the sample for the second sub-research question. The challenges include;

- **ENERGY**: Includes mission-oriented projects that are aimed at providing secure, clean and efficient energy in the European Union;
- **ENV**: Includes mission-oriented projects that focus on developing a solution for safeguarding the environment, changing climate action, resource efficiency and raw materials;
- **FOOD**: Includes mission-oriented projects that are focused on providing solutions for improved food security, sustainable agriculture and forestry, marine and maritime and inland water research;
- **HEALTH**: Includes mission-oriented projects focused on improving public health, addressing demographic change and for public well-being;
- **SECURITY**: Includes mission-oriented projects directed towards providing secure societies - protecting freedom and security of Europe and its citizens;
- **SOCCHAL-CROSST**: Includes mission-oriented projects directed at developing solutions for Cross-theme societal challenges(i.e. initiatives that aim to address a combination of more than one societal challenge)
- **SOCIETY**: Includes mission-oriented projects directed at developing solutions for inclusive, innovative and reflective Societies within the European Union;
- **TPT**: Includes mission-oriented projects focused on providing smart, green and integrated transport

For the third sub-research question, the sample is the same as for the first sub-research question. Thus, the top 12 European economies form the sample. Lastly, the fourth sub-research question utilizes the same sample from the second sub-research question, thus comprises eight societal challenges. The only addition for these two sub-research questions is the inclusion of the column - SME Flag to identify whether the organization is an SME or not.

In order to judge the standard of scientific research conducted, it is necessary to have an idea of the quality of research. Reliability and validity are the two most important measures to judge the quality of a study. *Reliability* refers to the consistency of recreating the results in different occasions of observation. The data that is used to address the main research objective is obtained by selectively reducing the CORDIS database to fit the scope of the objective. If the research methods as mentioned above in the section 3 are recreated, the results yield can be recreated repeatedly.

Secondly, *validity* is a measure of the extent to which the research objective of the study is actually measured. The research objective, as stated above, is to determine the current degree of private participation in European mission-oriented initiatives. By following the research methodology to selectively reduce the CORDIS database, this research accurately determines the solution specifically for the answering individual sub-research question and as a result, the main research objective. To be more specific, this study demonstrates *construct validity*, which can be defined as the degree to which the outcomes of a measure fits the theory on which it is based. In case of the first sub-research question, the construct for which the extent of private participation is explicitly analyzed is the *Country* in which mission-oriented research is conducted, while for the second sub-research question, the specific *societal challenge* addressed by the initiative is analyzed.

The constructs for the third and fourth sub-research questions are inclusive of those from the previous two sub-research questions. In case of the third sub-research question, it analyzes the *SMEs* in the particular nation while that for the fourth is *SMEs* for the different societal challenges.

The *generalizability* of research findings can be defined as the applicability of the results in a different research settings or if conducted by another researcher. Hence, generalizability is also a form of external validity and adds to the quality of the research.The more generalizable a research, the more useful it is. The analysis conducted to address the main research objective(i.e. to identify the extent of private participation in European mission-oriented research), can be recreated externally or in a different scientific setup and would yield the same results by following the research methodology as mentioned above. Additionally, as this thesis is used to quantitatively research a large data sample, the results obtained will be relatively more generalizable than alternative research methods.

3.2 Data Analysis

Data analysis begins with observing the population that is obtained by following the steps mentioned in the previous section. All raw data in the *CORDIS-Export* sheet is selected, and a pivot table is inserted for comparing the entries in two or more columns. The data is maintained as a new Microsoft Excel workbook, namely *Final Lists Proportion*. This spreadsheet will contain the final data sets that are visualized using Python programming language. A pivot table is used to combine items of a larger table as Filters, Rows, Columns or Values for summarizing the counts, sums or other statistics of each field in the main table. Therefore, the pivot table allows the researcher to compare individual fields to others and form causal relationships between the data. For each sub-research question, separate pivot tables are created and copied for answering the question.

3.2.1 Instrument Design

As mentioned above, pivot tables are used as an instrument to control the data and generate scientifically reliable and valid results. For the first sub-research question, the field *Project Acronym* is populated in *Rows*; the fields *Country* and *Legal Entity Type Description* is populated in *Columns*, and the *Count* of *Project Number* is populated in *Values*. This provides the pivot table for the first sub-research question which can be observed in Figure 11 (See Appendix A).

Similarly, for the second sub-research question, the field *Project Acronym* is populated in *Rows*; the fields *Thematic Priority Abbreviation* and *Legal Entity Type Description* is populated in *Columns*, and the *Count* of *Project Number* is populated in *Values*, which obtains the pivot table for the second sub-research question as observed in Figure 13 (See Appendix A).

The pivot table is designed similar to that for the first sub-research question with the addition of the field *SME Flag*. The pivot table for this sub-research question can be observed in Figure 12 (See Appendix A).

Lastly, the pivot table for the fourth sub-research question includes the field *SME Flag* in *Columns* along with the exact fields used in the pivot for the second sub-research question. The pivot table for this sub-research question can be observed in Figure 14 (See Appendix A).

The pivot tables obtained provides an overview of the number of mission-oriented initiatives with private participation, the number of different types of actors in each initiative (i.e. public, private, research organization etc.), the number of SMEs, and in which country or type of societal challenge the initiative is being conducted, based on the aim of the question. The **Subtotal** and **Grand Total** are also displayed in the pivot table. For the first and second sub-research questions, the **Subtotal** is the sum of the total number of actors in a project per country/societal challenge (i.e. the sum of all types of actors in that country/societal challenge), and the **Grand Total** it the sum of actors across all countries/societal challenge for that corresponding project. On the other hand, the third and fourth sub-research questions are for analyzing the extent of SMEs in mission-oriented initiatives. Therefore for these two sub-research questions, **Subtotal** is the sum of the total number of private actors in a project per country/societal challenge, and the **Grand Total** is the sum of private actors in that corresponding project across all countries/societal challenge in that project.

3.2.2 Data Calculation

The goal of this thesis is to identify the *extent/degree* of private participation in mission-oriented projects. For this reason, a logical function is used in Microsoft Excel to obtain the proportion of private actors in each project. This logic function is also utilized to eliminate values for specific countries or societal challenges that produce skewed results (for ex: if the count of private actors in a mission-oriented initiative is 0 then the overall ratio will be indefinite), which is discussed in further detail in the next section. The logical diagrams for the first two sub-research questions (i.e. for identifying the extent of private participation in mission-oriented initiatives per member nation or per societal challenge type) is displayed in Figure 1 below. The logical function for the third and fourth sub-research questions (i.e. for identifying the extent of SME participation in mission-oriented initiatives per member nation or per societal challenge type) is displayed in Figure 2 below.

By referring to the logical functions in the Figures. 1 and 2, it can be observed that if the **Subtotal** is equal to 0, the corresponding cell is be populated by a hyphen(-). When the **Subtotal** is equal to zero(0) for a particular country/societal challenge, it indicates that the corresponding project is not being conducted in that country/societal challenges. The hyphen(-) is used as a marker, which will be later used in the Python code and excluded from the results. The reason behind using the hyphen(-) to exclude an initiative from the sample is explained in the following section.

Box plots are generally analyzed with the help of specific statistical indicators. These indicators provide a better understanding of the distribution of the box plots and can be used to derive inferences from the results. The statistical indicators are calculated for the results of each sub-research question. These include;

- **Minimum**: Indicates the lowest value observed in the results
- **Quartile 1**: Comprises the bottom 25 percentile of all results obtained from the analysis
- **Median**: Indicates the central value of the results obtained, i.e. 50% of results lie above or below the median

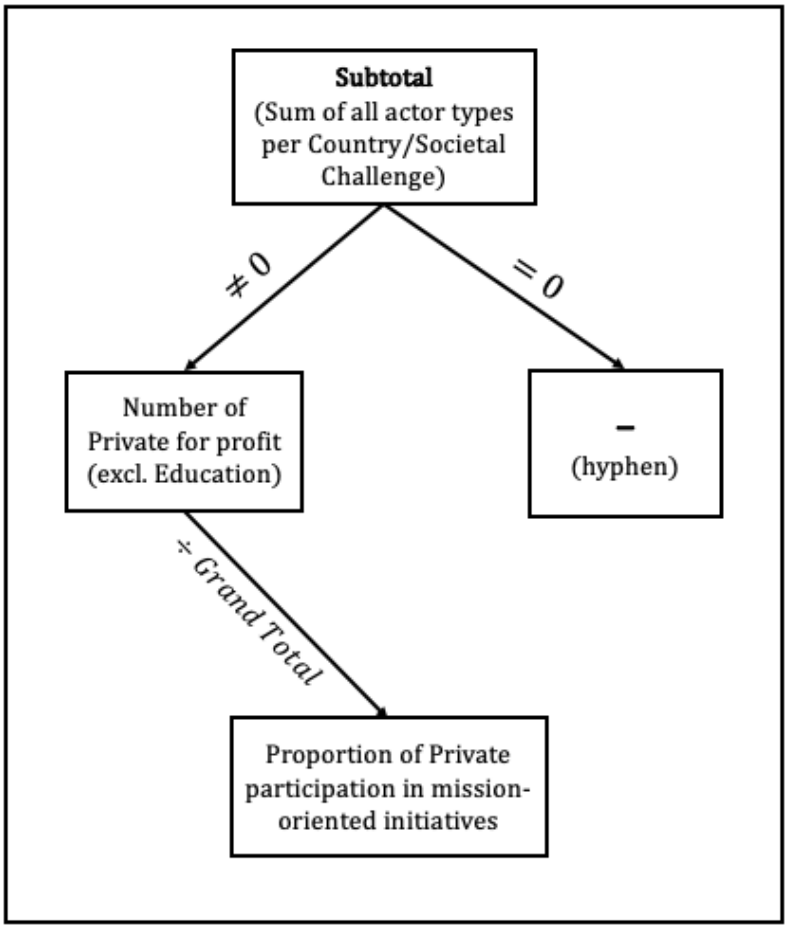

Figure 1: Logical Diagram - Proportion of Private participation in European Mission-oriented Initiatives

- **Quartile 3**: Comprises the top 25 percentile of all results obtained from the analysis (75% of all results fall below quartile 3)
- **Maximum**: Indicates the highest value observed in the results
- **Range**: Indicates the range of the whole plot, i.e. the difference between the Maximum and Minimum value
- **Inter-Quartile range**: Indicates the difference between Quartile 3 and 1. The inter-quartile is a measure of the variability of the results obtained from the data analysis
- **Mean**: The average value of the obtained results

3.2.3 Data Visualization

After obtaining the final lists for each of the sub-research questions, the data is visualized to provide a better interpretation of the extent of private participation in European mission-oriented initiatives. As the number of initiatives vary per country or societal challenge, visualizing the data on excel obtains skewed plots because the sample for each sub-research question would be inaccurate. Hence, a code is created in Python programming language, and the data is visualized in the form of box/whisker plots.

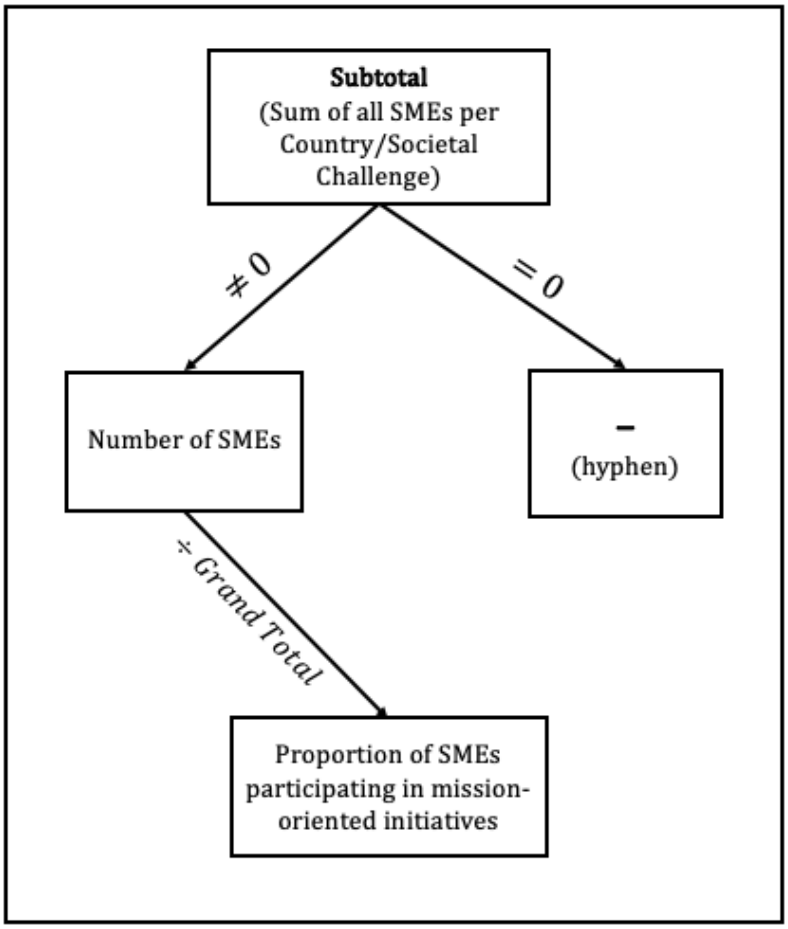

Figure 2: Logic Diagram - Proportion of SME participation in European Mission-oriented Initiatives

In order to read, manipulate and visualize the data from the Microsoft Excel sheet into box plots, specific data libraries are imported into the program. These libraries include;

- **Pandas**: Pandas is an open-source software library for the programming language Python and is used for data manipulation and analysis. Pandas is imported to read the Microsoft Excel sheets for each of the sub-research questions.
- **Numpy**: Numpy is another open-source software library for Python programming language and is used for providing support to manipulate large arrays of data or matrices. As explained in the previous section (see 3.2.2), when the **Subtotal** (i.e. the sum of all types actors in a particular country/societal challenge) is equal to zero(0), then the cell is displayed with a hyphen(-). In this case, Numpy is used to read all cells that display hyphen(-) and replace them with **NaN (Not a Number)**. All the cells filled with **NaN** are excluded from the sample of that particular country/societal challenge by virtue of the Numpy library. This ensures that samples for each sub-research question are accurate, which will generate accurate box plots.
- **Seaborn**: Seaborn is a software library for Python programming language and is used for visualizing statistical data. For this thesis, Seaborn is used to display the data in form of box/whisker plots.

- **Matplotlib.pyplot**: Matplotlib.pyplot is another software library for Python programming language and is used for the visualization of statistical data. For this thesis research, matplotlib.pyplot is used to define the axes of the plots obtained.

The code used for data visualization is written and edited using Visual Studio Code editor. Separate codes are written for each sub-research question, and can be referred in the appendix A (see Figures. 7, 8, 9, 10).

4 Results

Section 3 above provides a detailed research methodology that is used for analyzing data extracted from CORDIS to address the primary research objective. The data is analyzed following the systematic procedure, and box plots for individual sub-research questions are obtained. In this section, the results obtained from the box plots are described in brief.

The central objective of this research is to identify the extent of private participation in mission-oriented innovation in European-mission oriented policy. By referring to the literature, the main research question is broken down into four sub-research questions, which can be answered together to address the main research objective. The first sub-research question identifies the proportion of private actors from a sample of 12 European member states. In contrast, the third sub-research question identifies the participation of SMEs in the same sample. For the second sub-research question, the proportion of private actors is analyzed from the sample, including the eight societal challenges in the CORDIS database, while the fourth sub-research question identifies the proportion of SMEs using the same sample. The number of mission-oriented projects conducted in the different countries from the sample (to 12 European economies in the data extract) varied. Hence, visualizing data using a Microsoft Excel spreadsheet yielded inaccurate results. In order to exclude mission-oriented initiatives from the sample, a code is written in Python programming language and the same is used to visualize the data (discussed in section 3.2.2, also refer Figures. 7, 8, 9, 10). The results obtained from the data is represented in the form of box plots.

4.1 Private participation in the top 12 European economies

Figure 3 provides a visual representation of the extent of private participation in the top 12 European economies, including Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden, Turkey, and the United Kingdom. The box plots are arranged in the descending order of their *median* value when reading the plots from the left-hand side to the right. In total, 4743 mission-oriented projects are being conducted or have already been completed across the top 12 European economies. However, as previously mentioned, the number of projects varies per nation because not all projects are conducted in every nation. It is observed from the population that smaller economies have a lower number of mission-oriented projects, and this trend is also observed in the sample of the top 12 European economies. For the purpose of evaluating the box plots, their statistical indicators, including the minimum, first quartile, median, third quartile, maximum, range, inter-quartile range and mean are calculated can be referred from table 1.

From the box plots in Figure 3 it can be observed that the inter-quartile range for the plots of all 12 countries is very nearly similar. As mentioned previously, the **Inter-quartile range** is a measure of the spread or variability of the data. It is a difference between the third (Quartile 3) and the first quartile (Quartile 1). This range comprises middle 50% of all the results obtained. Therefore, it can be deduced from the plots that there is not much variability in the proportion of private actors in mission-oriented initiatives across the top 12 European economies. The **average** proportion of private participants is separated to a minor extent. However, there is a greater difference in the **median** proportion of private actors across the countries.

The median value of private participants in Spain(0.46) and Italy(0.44) is considerably higher than that in Turkey(0.31) and Poland(0.29).

Additionally, the overall **range** is also the same across these nations. For most of the countries, the sample displays central tendency/zero skew. However, the results obtained from the samples for Poland has a positive skew (towards the top), which indicates that the long tail of mission-oriented initiatives consists of a higher proportion of private participants.

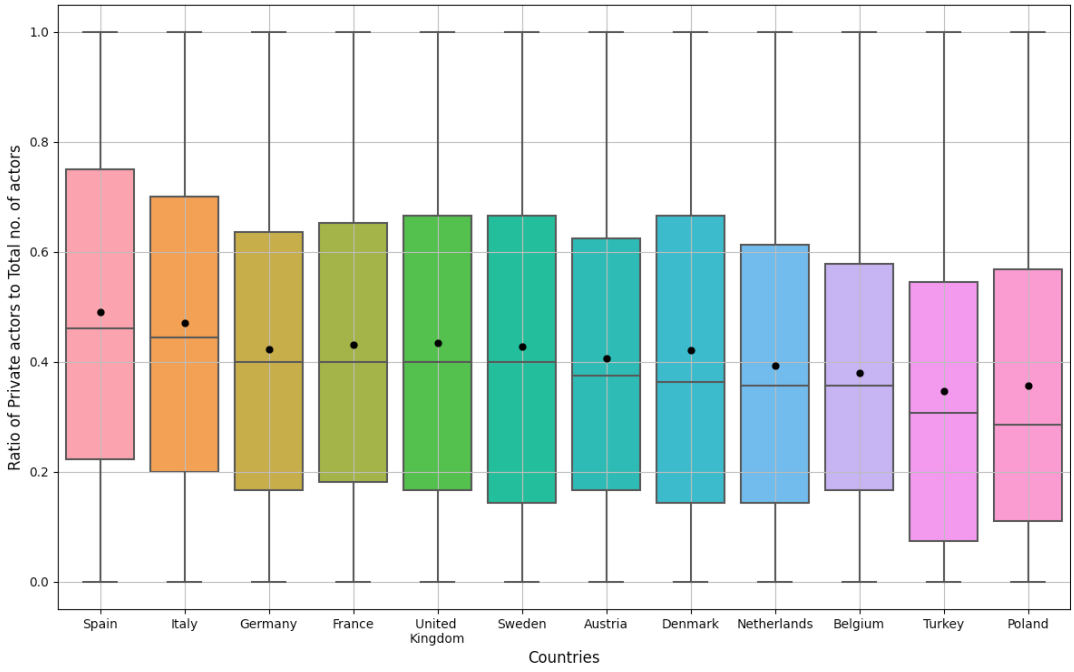

Figure 3: Box Plot - Proportion of Private participants in the top 12 European economies

There are no outliers observed in the box plots for any of the 12 countries and hence, does not require more profound analysis of the data. The observations made from these plots also are discussed in further detail in the next chapter 5.

Table 1: Statistical Indicators - Proportion of private actors in the top 12 European economies

Statistical Indicators	Spain	Italy	Germany	France	United Kingdom	Sweden	Austria	Denmark	Netherlands	Belgium	Turkey	Poland
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Quartile 1	0.22	0.2	0.17	0.18	0.17	0.14	0.17	0.14	0.14	0.17	0.07	0.11
Median	0.46	0.44	0.4	0.4	0.4	0.4	0.38	0.36	0.36	0.36	0.31	0.29
Quartile 3	0.75	0.7	0.64	0.65	0.67	0.67	0.63	0.67	0.61	0.58	0.55	0.57
Maximum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Range	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Inter Quartile Range	0.53	0.50	0.47	0.47	0.50	0.52	0.46	0.52	0.47	0.41	0.47	0.46
Mean	0.49	0.47	0.42	0.43	0.43	0.43	0.41	0.42	0.39	0.38	0.35	0.36

4.2 Proportion of Private actors in the 8 Societal Challenges

Figure 4 provides a visual representation of the extent of private participation across the eight Societal challenges that include ENERGY, ENV, FOOD, HEALTH, SECURITY, SOCCHAL-CROSST, SOCIETY and TPT. The box plots are arranged in the descending order of their *median* value when reading them from left to right. In total, there are 4743 mission-oriented projects with private participants in this analysis. Similar to that observed in the sample for the first sub-research question, the number of projects varies in each societal challenge. The statistical indicators, including the minimum, first quartile, median, third quartile, maximum, range, inter-quartile range and mean are calculated and mentioned in the table 2.

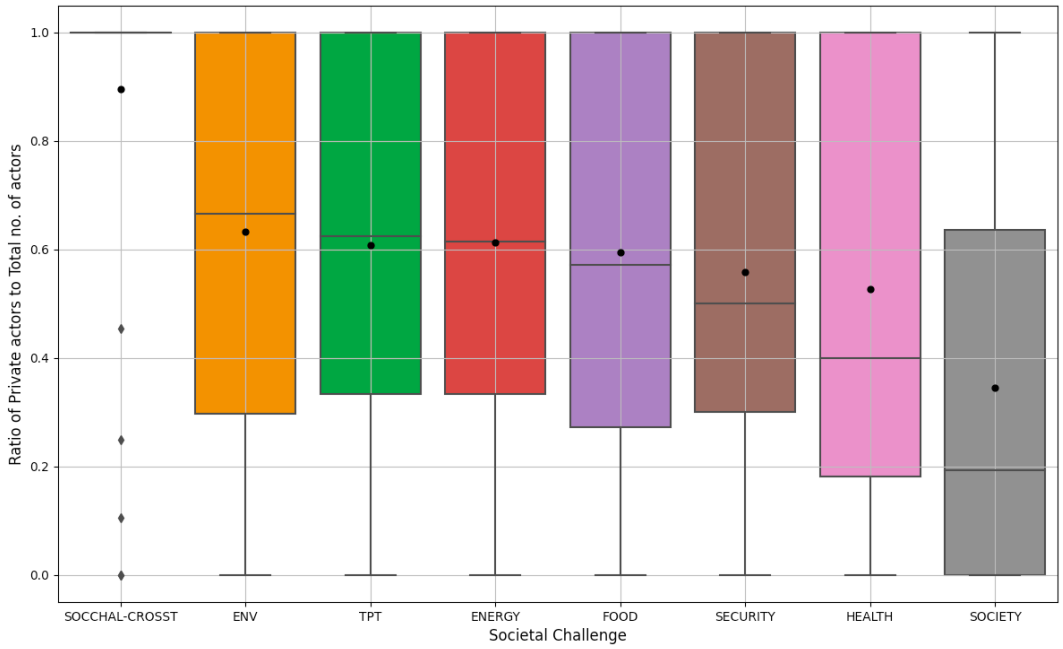

Figure 4: Box Plot - Proportion of Private actors in 8 Societal Challenges

From the box plots in Figure 4 it can be observed that the inter-quartile range for the plots of the eight societal challenges is dissimilar. The inter-quartile range for societal challenges of ENV, TPT, ENERGY, FOOD, SECURITY and SOCIETY are nearly similar. However, the spread for the proportion of private actors in mission-oriented projects for SOCCHAL-CROSST and HEALTH differ from the remaining. The box plot obtained for the SOCCHAL-CROSST has an inter-quartile range of 0 because nearly all actors participating in projects addressing this challenge are private. The average proportion of private participants is nearly similar for initiatives aimed at resolving the challenges of ENV(0.63), TPT(0.61), ENERGY(0.61), FOOD(60), SECURITY(56), and HEALTH(0.53). The plots for ENERGY, FOOD, SECURITY, HEALTH and SOCIETY are positively skewed (towards the top), indicating that the long-tail of initiatives have a higher proportion of private actors on an average. The average proportion of private actors in SOCCHAL-CROSST(0.90) indicates that a high majority of actors participating in these initiatives are private. This result is because a majority of the actors participating in SOCCHAL-CROSST related initiatives are private.

SOCIETY(0.35) has the lowest average proportion of private actors. The plot is skewed towards the right (lower valuer), which indicates that, on average, the proportion of private actors in initiatives addressing SOCIETY-related challenges is relatively lower. On the other hand, ENV and TPT are negatively skewed, indicating that long-tail initiatives have a relatively low proportion of private participants. There are outliers observed in the box plots for SOCCHAL-CROSST. **Outliers** can be defined as abnormal values that are numerically further away from others in the observation. The results will be discussed in more detail in the next section 5. In this case, these are due to a minor few initiatives that have a much lower average proportion of private participants.

Table 2: Statistical indicators - Proportion of private actors in 8 societal challenges

Statistical Indicator	**ENERGY**	**ENV**	**FOOD**	**HEALTH**	**SECURITY**	**SOCCHAL-CROSST**	**SOCIETY**	**TPT**
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quartile 1	0.33	0.30	0.27	0.18	0.30	1.00	0.00	0.33
Median	0.62	0.67	0.57	0.40	0.50	1.00	0.19	0.63
Quartile 3	1.00	1.00	1.00	1.00	1.00	1.00	0.64	1.00
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Range	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Inter Quartile Range	0.67	0.70	0.73	0.82	0.70	0.00	0.64	0.67
Mean	0.61	0.63	0.60	0.53	0.56	0.90	0.35	0.61

4.3 Proportion of SMEs in the top 12 European economies

Figure6 provides a visual representation of the extent of SME participation in the top 12 European economies mentioned previously. The box plots are arranged in the descending order of their *median* value when reading them from the left-hand side to the right. To evaluate and draw results from the box plots, their statistical indicators are calculated and can be referred from table 3.

Table 3: Statistical Indicators - Proportion of SMEs in top 12 European economies

Statistical Indicators	Spain	Italy	Germany	France	United Kingdom	Sweden	Austria	Denmark	Netherlands	Belgium	Turkey	Poland
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Quartile 1	0.11	0.08	0.13	0.11	0.10	0.11	0.08	0.09	0.12	0.08	0.09	0.08
Median	0.25	0.20	0.27	0.25	0.23	0.25	0.2	0.22	0.25	0.19	0.21	0.19
Quartile 3	0.5	0.33	0.54	0.46	0.44	0.44	0.38	0.42	0.5	0.33	0.38	0.33
Maximum	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Range	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Inter Quartile Range	0.39	0.25	0.41	0.35	0.34	0.33	0.29	0.33	0.38	0.26	0.28	0.26
Mean	0.36	0.26	0.39	0.35	0.34	0.34	0.29	0.32	0.37	0.25	0.28	0.25

By referring to the box plots in Figure 6, it is observable that there is a difference in the inter-quartile range for these plots. This indicates that there is some variability in the proportion of SMEs in European mission-oriented initiatives in the top 12 European economies. However, it is also observable that the median value of SME proportion is very similar. The plots for Germany, Spain, the Netherlands and the United

Kingdom display positive skewness, which indicates that the long-tail of initiatives have a relatively high proportion of private participants compared to the proportion of other actors. The remaining countries display almost zero skew. The plots for France, Sweden, the United Kingdom, Denmark, Turkey, Italy, Austria, Belgium and Poland all display a significant number of outliers. The inter-quartile range is very similar for Germany, Spain and the Netherlands, while the overall range for these countries is equal.

From the box plots for sub-research questions 1 and 3 (see Figure 3 and Figure 6 respectively), a few noticeable observations are derived for the countries of the Netherlands and Italy. The Netherlands has a relatively lower proportion of private participants in mission-oriented initiatives as compared to Italy. However, the proportion of SMEs in the Netherlands is much higher than in Italy. This observation will be further discussed in more detail in the next section.

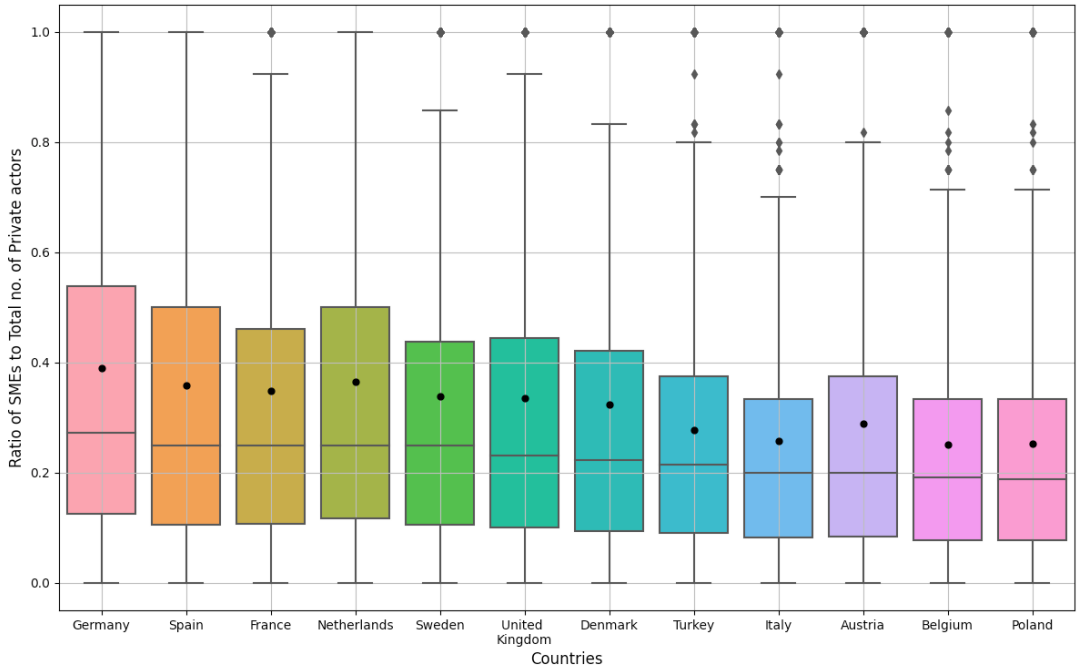

Figure 5: Box Plot - Proportion of SMEs in top 12 European economies

4.4 Proportion of SMEs in the 8 societal Challenges

Table 4: Statistical indicators - Proportion of SMEs in 8 societal challenges

Statistical Indicators	ENERGY	ENV	FOOD	HEALTH	SECURITY	SOCCHAL-CROSST	SOCIETY	TPT
Minimum	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00
Quartile 1	0.40	0.56	0.50	0.50	0.33	1.00	0.50	0.13
Median	0.75	1.00	1.00	1.00	0.67	1.00	1.00	0.50
Quartile 3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Range	1.00	1.00	1.00	1.00	1.00	0.40	1.00	1.00
Inter Quratile Range	0.60	0.44	0.50	0.50	0.67	0.00	0.50	0.87
Mean	0.67	0.80	0.77	0.75	0.65	0.98	0.74	0.57

Figure 6 provides a visual representation of the extent of SME participation across the 8 Societal challenges, which is the same sample used in the analysis of sub-research question 2. The box plots are arranged in the descending order of their *median* value when reading them from the left to the right. In total, there are 4218 mission-oriented projects in which there SMEs are actively participating. The statistical indicators are mentioned in the table 4.

From the box plots in Figure 6 it can be observed that the inter-quartile range for the plots of the eight societal challenges is dissimilar. This indicates some variability of SME proportion across the eight societal challenges. The results observed for societal challenges of ENV(0.44), FOOD(0.50), HEALTH(0.50), and SOCIETY(0.50) have very similar proportions of SMEs in mission-oriented initiatives. The plot for SOCCHAL-CROSST is inconclusive as the inter-quartile range is 0. As observed from the results in section 4.2 (see 4) majority of actors participating in SOCCHAL-CROSST related projects are private. By comparing the aforementioned with the results observed in Figure 6, it can be derived that a majority of these private actors are, in fact, SMEs. The details will be discussed in more detail in the next section. The results for all societal challenges, including ENV, FOOD, HEALTH, SOCCHAL-CROSST, SOCIETY, ENERGY and SECURITY, are negatively skewed, while the result for TPT is positively skewed. There are a few outliers for SOCCHAL-CROSST, which will be discussed in more detail in section 5.

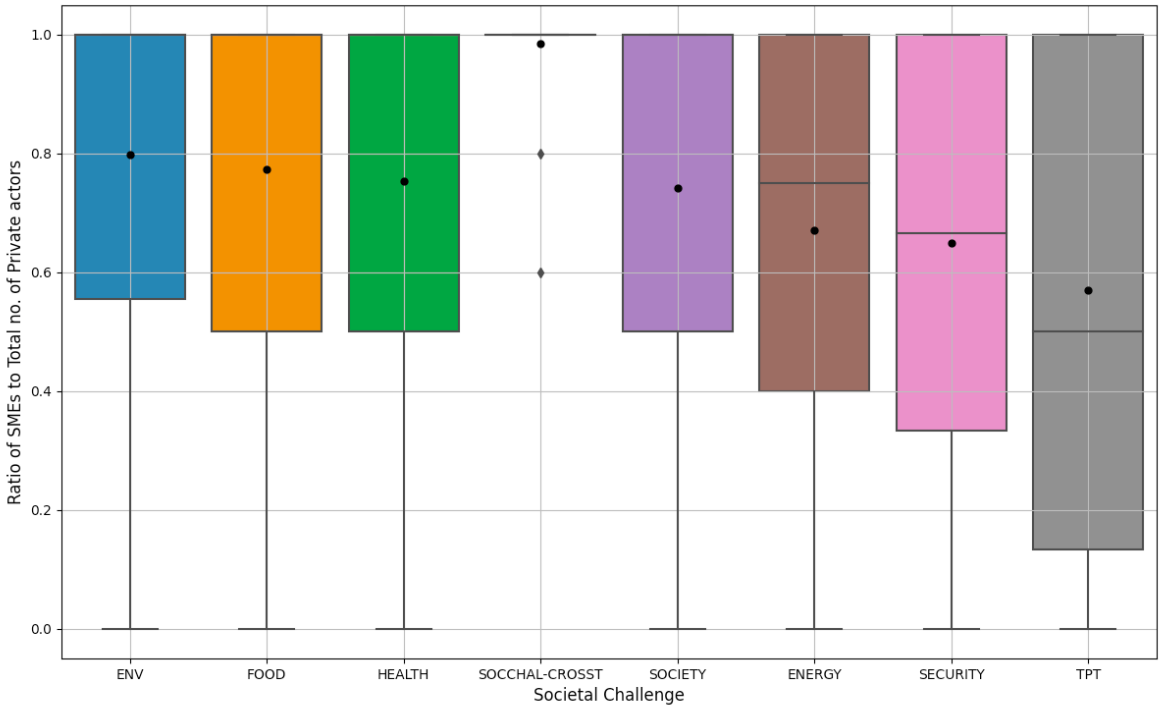

Figure 6: Box Plot - Proportion of SMEs in 8 Societal Challenges

4.5 Opportunities and shortcomings of the CORDIS database

Analyzing the CORDIS database for the purpose of addressing the primary research objective yielded results as discussed in the previous section. Based on the literature on mission-oriented innovation policies as mentioned in section 2, it can be deduced that information available in the CORDIS database has tremendous potential for scientific research and policy making. However, the database also falls short on some instances, because it does not explicitly portray specific fields that would be useful to identify the extent of private participation within the European Union. In order to identify the extent of private participants in European mission-oriented innovation, the data is analyzed to identify the proportion of private organizations and SMEs from the respective samples.

As discussed in the section 2, it is understood that the CORDIS database is useful for identifying the extent of private participation in mission-oriented innovation initiatives that are funded by various public funds including the Horizon 2020 framework programme in countries all over the globe. As mentioned previously, the CORDIS database contains specific fields that highlight the type of organization participating in an initiative, whether an organization is an SME, the specific country in which the initiative is conducted, the net spent (in Euros) by the organization/actors and various other fields. As understood by the analysis conducted in this paper, the CORDIS database provides the necessary information for studying about mission-oriented innovation in greater detail. This paper particularly focuses on the extent of *private* participation, however it can also be utilized to identify the degree of participation of the *public sector*, *research organizations* as well as *educational institutions*. Additionally, by utilizing the figures regarding expenditure and total costs, it will be possible to analyze which societal challenge or industrial sectors or country has to focus more towards particular research in order to tackle the corresponding societal challenge.

As mentioned in the beginning of this section and based on the analysis of the CORDIS database in this thesis, it is also evident that CORDIS misses out on highlighting some important fields that can add to the value of the database for scientific research and policy making purposes. Based on the theory is section 2.3 and section 2.4, it is understood that data regarding the industrial sector of the innovation and the technology developed can provide a better foundation for understanding the degree of participation in European mission-oriented research. This data can be used for future research and for policy making as it can be used for developing causal relations between the individual fields in the dataset to better understand how effective is the current implementation of mission-oriented research in the European Union.

In the next section 5, the opportunities and shortcomings of the CORDIS database are discussed by drawing back from the literature on mission-oriented innovation to provide a more detailed background of the value of recording and maintaining such data in export.

5 Discussion

The central objective of the study (refer section 1.4) is to identify the extent of private participation in European mission-oriented innovation policy. For this reason, the data extracted from CORDIS is analyzed using a quantitative research methodology. Following the data analysis, the results are visualized using Python code to generate the box plots for each sub-research question. This section discusses the results mentioned above in more detail by relating them to the theory and consolidating it to answer the main research objective of this study.

5.1 The extent of private participation in European Mission-oriented Innovation policy

The results discussed in section 4.1, highlight that there is minimal variability in the proportion of private participants in the top 12 European economies. This indicates that the extent of private participation in European mission-oriented initiatives is relatively similar. The results section shows that the extent of private participation across the top 12 European economies is nearly identical. By conducting a more in-depth analysis of the data set, the Table 5 is obtained, which contains a distribution of mission-oriented initiatives by country and highlights the corresponding number of private actors, SMEs and the total number of actors in these projects.

The results obtained for the first sub-research question (see 3) display that the countries of Spain(1409), Italy(1372), Germany(1312), the United Kingdom(1154), France(1116), the Netherlands(744), Austria(430) and Sweden(430) have an above average (approx 43%) proportion of private participants in mission-oriented initiatives. By referring to Table 5(see Appendix A), it is observable that Denmark, Turkey and Poland have relatively fewer mission-oriented initiatives that the remaining economies in the sample, and they also have a lower count of mission-oriented initiatives. The proportion of mission-oriented initiatives with private participants is relatively low in Poland(34%) and Turkey(44%). However, the results in Figure 3 indicate that Denmark has a greater extent of private participation than Turkey and Poland. The in-depth analysis identified that proportion of in mission-oriented initiatives with private participation in Denmark is the highest for the entire sample. From a total of 698 projects performed in the country, 640 have private participants, which indicates that approximately 92% of all projects in Denmark have private participants with an average participation of approximately 42%. Another noteworthy observation can be drawn from the results for Belgium as seen in Figure 3. By analyzing the Table 5) (see Appendix A) it is observed that although Belgium has a total of 1487 mission-oriented projects, only 23%(341) of these have private participants. Literature on the dynamics of national innovation systems points to the fact that 'the world is spiky' (Florida, 2005), meaning that different geographical regions/nations differ in the very knowledge, skills and resources that they possess. However, this knowledge required to foster innovations and spur smart economic growth is generally 'tacit' in nature and hence, it is not easily transferable across national/regional borders (Bathelt et al., 2004; Boschma, 2005). As a result, the available knowledge and resource are often unevenly distributed across geographical boundaries, which results in clustering of the knowledge within

the bounds of a country or region (Heimeriks & Boschma, 2014). Therefore, the knowledge and resources within a nation are often specific to the actors in that region. Consequently, it is highly probable that the extent of private participants in mission-oriented initiatives will vary across national boundaries. Upon analyzing the results discussed above it is observable that the extent of private participation does vary across the nations that make up the sample. As mentioned in section 2.1, it is understood that the state should possess the right set of dynamic capabilities to spur mission-oriented exploration and exploitation. With these capabilities, governments can crowd-in private actors for innovating in new areas of growth and simultaneously benefit from the activities of these private firms and continuously add to the entire value chain. Based on this theory, it is possible that the government of Denmark may possess better dynamic capabilities to spur mission-led growth than governments of other nations. However, this is not conclusive and will require follow-up qualitative research in order to be identified. Additionally, the risk of having high degree of private participation in mission-oriented initiatives is that the private actors would over-exploit the resources provided by the state, and hence result in commercialization of the resultant innovations. Drawing from theory, this is not suitable as successful mission-oriented innovation requires equal participation of both public and private actors.

The results obtained for the second sub-research question, as discussed in section 4.2 (see figure 4), highlight that for initiatives aimed at resolving societal challenges related to ENERGY, ENV, FOOD, HEALTH, SECURITY, SOCCHAL-CROSST, and TPT have a high extent of private participation. For a better understanding of the results, table 6(see Appendix A) is obtained by conducting an in-depth analysis of the data. This table provides a distribution of mission-oriented initiatives by societal challenge and highlights the corresponding number of private actors, SMEs and the total number of actors in these projects. However, from the results obtained for mission-oriented initiatives for addressing SOCIETY related initiatives, it is observable that the extent of private participants is relatively lower. Out of a total of 324 projects, only 204 (62%) initiatives have private participation. Mission-oriented initiatives related to SECURITY and SOCCHAL-CROSST displays some noteworthy results. As mentioned in the above section 4.2, it can is understood that the mission-oriented SOCCHAL-CROSST related problems are nearly entirely comprised of private participants. There are 38 projects with private participants from a total of 40 which indicates that 95% of all projects have private organizations participating in them, out of which 90% of all the actors in SOCCHAL-CROSST related initiatives are private. However, it is tough to predict whether the high proportion of private participants in mission-oriented initiatives related to SOCCHAL-CROSST positively or negatively affect it. As mentioned above, it is necessary that there is a balance between number of the public and private actors participating in an initiative. Similar to the above observation, it is possible that the high private participation may cause commercialization of initiatives and hence, the state may loose out on reaping the benefits of these initiatives.

By conducting an in-depth analysis of the results obtained from the third sub-research question (see table 5) its is observable that Spain(989), Italy(946), Germany(825), the United Kingdom(791), France(603), the Netherlands(503), Austria(242), Sweden(224), Belgium(357) and Poland(112) have relatively high extent

of SME participation. On the contrary, Denmark(223) which has the highest relative private participation, records the relatively lowest ratio of mission-oriented projects with SME participation. The results obtained for sub-research question four (see table 6), highlight some noteworthy observations for SOCCHAL-CROSST(38), SOCIETY(173) and TPT(977) related societal challenges. In the case of SOCCHAL-CROSST related initiatives, it is observed that all the private actors participating are SMEs. On the other hand, initiatives aimed at TPT(80%) and SOCIETY(84%) related challenges have a relatively low proportion of SME participation. Therefore, it can be inferred that mission-oriented initiatives aimed at addressing challenges related to TPT and SOCIETY are not as entrepreneurial as those for other societal challenges. As mentioned in theory, it can be understood that developing suitable innovations require collaboration between both incumbents and SMEs. Although the nations or societal challenges which are highly entrepreneurial (i.e., having high SME participation) may possess novel knowledge and skills for creatively disrupting efforts across the value chain, it is still highly likely that they may not possess the required capital and skills to develop and commercialize these innovations, and hence could fail out on addressing the relevant problems. To better understand the extent of private participation in mission-oriented initiatives, the results obtained for the third and fourth sub-research questions are compared to those obtained from the first and second sub-research questions. It is noteworthy to look at the extent of private and SME participation, especially in Italy and the Netherlands. Referring to Figure 3, it can be observed that the results derived for Italy display a relatively high proportion of private participants in mission-oriented initiatives as compared to that in the Netherlands. However, from Figure 6, it is observable that the extent of SMEs participating is much lower in Italy than in the Netherlands. The extent of private participants in initiatives related to TPT (58%) in the Netherlands is considerably lower than in Italy (83%), which displays a greater extent of private participation. By referring to Tables 7 8, 9 and 10 (see Appendix A), it is observable that the Netherlands displays very even participation of private actors and SMEs in mission-oriented research. This indicates that the mission-oriented initiatives in the Netherlands are relatively more entrepreneurial than in Italy. As mentioned in section 2.5, theorists have highlighted that SMEs are more likely to create disruptive innovations than incumbent firms (Hockerts & Wüstenhagen, 2010) because they are more flexible towards developing new competencies. Incumbents, on the other hand, usually tend to maintain their market position by incrementally building on their existing competencies (Smink et al., 2015). More importantly, theory suggests that addressing contemporary grand challenges requires dynamic collaborations between both incumbents and startups (Hekkert et al., 2007; Hockerts & Wüstenhagen, 2010). It can be concluded that the Netherlands has a relatively more balanced number of incumbents and SMEs, while in Italy there is s smaller extent of SME participation. Based on this theory on transition studies, it is highly possible that mission-oriented initiatives in the Netherlands can result in more suitable and desirable innovations that are required to address grand challenges faced in these countries. However, the results are not conclusive and will require follow up research to identify the factors that impact the SME and incumbent participation in the aforementioned countries.

From Tables 7, 8, 9 and 10 (see Appendix A) and the results discussed in the previous section, it is observed that the proportion of private participants in mission-oriented initiatives related to ENERGY, ENV, HEALTH, SECURITY and SOCIETY in the countries including Denmark, France, Germany, the Netherlands and the United Kingdom are relatively very similar. These nations have relatively above average proportion of private participation as compared to other nations in the same societal challenges. The in-depth analysis of the results obtained from CORDIS data highlights that Spain and Italy have relatively the highest extent of private participation in mission-oriented initiatives for addressing the societal challenges of ENERGY, ENV, FOOD, SECURITY and SOCIETY when compared to other nations. As stated in the literature on national innovation systems, it is understood that transferring tacit knowledge and expertise across borders requires geographical proximity between regions. This indicates that knowledge is path-dependent as well also place-dependent (Heimeriks & Boschma, 2014). However, knowledge creation is still dynamic in nature and can be branched out for creating new proprietary knowledge and skills (Heimeriks & Balland, 2016; Schumpeter, 1934). In the case of the aforementioned member states of the European Union, it can be deduced that actors have taken advantage of the geographical proximity to their neighbours and increased their research and innovation efforts for addressing various societal challenges. However, in the case of nations such as Austria, Belgium, Poland and Turkey, is is very likely that the government does not possess an optimal entrepreneurial state (Rodrik et al., 2004) by which they can drive private organizations to invest and actively participate in the early stages of innovation. This is why the results obtained for these nations display a relatively low degree of private participation.

As described in the section 4 the results obtained for SOCIETY related challenges display a relatively lower degree of private participation in mission-oriented innovation when compared with other challenges. By closely observing the results and referring to the tables 7, 8, 9 and 10 (see Appendix A) it is noticeable that the highest degree of private participation in mission-oriented initiatives for addressing SOCIETY related challenges is mainly contributed by Spain and Italy.

Additionally, it is observed in the previous sections 2.2 and 2.4 that SOCCHAL-CROSST related challenges have a high degree of private participation. This is owing to the number of mission-oriented initiatives conducted for addressing SOCCHAL-CROSST associated challenges. In total, there are only 40 projects aimed at resolving this societal challenge and a vast majority (38) of these involve private actors. Additionally, it is noteworthy that 95% of the private actors participating are, in fact, SMEs. This also addresses the two outliers observed in Figure 6. The two initiatives displayed as outliers are the only initiatives that have private incumbent organizations participating.

It is observable that the results for SME participation (see Figure 5 in Turkey, Italy, Belgium, Austria, and Poland display multiple outliers. As discussed previously, the extent of SME participation in these nations is relatively lower than in other countries. As a result, it is derived that the outliers are caused due to a few initiatives with a relatively high degree of private participation. This indicates that there are increasingly more mission-oriented initiatives in which SMEs are actively participating.

5.2 Discussing the opportunities and challenges of the CORDIS database

The CORDIS database is selected as the central database for this research because it contains valuable information about the participants, fact sheets and figures related to a plethora of mission-oriented projects conducted within the European Union. Additionally, this database is readily available to the public, which makes it a suitable source of information for scientific research and similar studies that may be performed in the future. This section focuses on the need for certain data that is not presently maintained in the CORDIS database, but will be necessary for the effective implementation mission-oriented innovation policies.

In the previous section it is discussed that the CORDIS database can be utilized as a tool for scientific research as well as for steering policy making. This thesis primarily focused on identifying the extent of private participation in mission-oriented innovation initiatives encompassed in the Horizon 2020 framework programme in the European Union. The CORDIS database explicitly highlights specific data regarding the type of organization (whether private, public or research organization), the country in which the mission-oriented initiative is being carried out, if the organization is an SME or not, the total expenditure by private and public organizations (in Euros), the type of societal challenge as well as the number of private or public actors in a particular initiative. CORDIS is used as the central database for the propose of this thesis and obtains some useful results regarding the current extent of private participation is European mission-led research. The results of this thesis can be utilized and compared to the other available fields in the database. As per the discussions mentioned above in this section, it is understood that the extent of private participation is greater in larger economies. But, it is not known whether this difference in private participation is due to the dynamic capabilities of the governments or due to better knowledge sharing between the actors in these nations. By conducting a qualitative analysis of the data in future studies, it will be possible to understand the causal relationship between variables and identify the factors that drive/spur effective mission-oriented research within the European Union. These in order to understand the effectiveness or current degree of mission-oriented innovation in Europe as well as in other countries worldwide.

As discussed in literature (see sections 2.3 and 2.4), it is understood that available tacit knowledge, skills, human capital and other resources would be fragmented across the different member states of the European Union. This fragmentation can negatively affect what actors perceive of the available expertise and resources because they are more inclined towards utilizing knowledge that is available within their proximity (Mcloughlin et al., 2000). This tacit knowledge and resources are however, difficult to codify and thus not easily imitable either. Hence, it is very likely that different actors in the European Union would focus on various technologies based on the resources available within their technological reach.

However, upon analyzing the CORDIS database for identifying the extent of private participation in European mission-oriented innovation, it was derived that the database does not explicitly highlight which *radical innovation* or *breakthrough technology* is being developed in a particular mission-oriented project. Drawing back from literature, it can be understood that data regarding the *breakthrough technology* developed in a mission-oriented initiative can provide a deeper understanding regarding the innovative or technological solutions that actors are focusing on developing with their efforts and resources. Technological Innovations

systems are also dynamically much less complex when compared to National Innovation systems, which makes it easier to map all the relevant activities, actors and networks of actors that are involved in this system (Hekkert et al., 2007). Additionally, theory also indicates that it is highly likely that different *technologies* being developed may stand at different levels of maturity. As a result, the multiple public and private actors participating in the development of this theory will also have different levels of expertise and skills. Therefore, maintaining a field about the specific *innovation* or *technology developed* will provide a better understanding to researchers and policy makers regarding the specific innovations or advanced technologies that are being currently used to solve specific societal challenges. By doing so, researchers and policy makers can focus on utilizing the appropriate resources and methods for creating suitable innovations or technologies to address similar societal challenges globally.

Literature on *Sectoral Innovation Systems* previously discussed in section 2.3, highlights that resources, skills and knowledge that available with the actors differ across various industrial sectors. In his literature, R. R. Nelson and Winter (1997) has stated that sectors in which the growth of productivity is relatively lower also displayed lesser growth in their technological advancement. Theory also mentions that the lower productivity growth in a sector can lead to an imbalance of the socio-technological development of that sector (Kendrick, 1961; Ruttan & Salter, 1961) and hence, is likely that the degree of private and public actors will vary drastically. If an additional field regarding the *industrial sector* is maintained in the CORDIS database, it will be possible for researchers and policy makers to track which sectors are more innovative and develop more suitable solutions for addressing societal challenges while allowing them to identify the sectors that fall short in their efforts for developing solutions. By doing so, policy makers can focus public funding towards such sectors and create a socio-technical balance in the value chain. Additionally, it will allow them to identify which specific sectors are required to collaborate for addressing different societal challenges.

The addition of data such indicating the *'breakthrough technology'* developed and *'Industrial Sector'* in which a mission-oriented initiative is carried out will benefit in better understanding the extent of private and public participation within the European Union. By maintaining the aforementioned data will also provide a better foundation for scientists and researchers to conduct future research, as well as for policy makers to better understand the current dynamics of innovation within their geographical proximity and to steer mission-oriented innovation to effectively address grand challenges faced worldwide.

6 Reflection

The previous section provided a detailed discussion of the results obtained by analyzing the data extracted from CORDIS. These results add to the existing literature on mission-oriented innovation and provide a scope for future research in a similar context. This section will briefly discuss the theoretical and practical contributions of this thesis study. Lastly, it will draw back from the courses provided in the Management of technology programme to understand the relevance of this thesis on the same.

6.1 Theoretical Contributions

Recent literature on mission-oriented innovation policies has studied the formulation and implementation of mission-oriented policies for addressing greater social and environmental challenges faced by economies worldwide. Researchers have mentioned that addressing these challenges requires dynamic interactions and collaborations between the government and private actors in order to explore new growth opportunities and exploit them to generate desirable and inclusive innovations.

Although the literature on mission-oriented innovation highlights the need for public and private collaboration for spurring mission-led innovation, it does not explicitly mention the current extent of private participation. By quantitatively analyzing the archival data extracted from CORDIS, this study identifies the current extent of private participation in European mission-oriented innovation. Theorists have emphasized that addressing grand challenges requires the state to possess the right set of dynamic capabilities to attract private businesses for contributing towards mission-led growth. By identifying the current extent of private participation in European mission-oriented innovation policy, this thesis provides a foundation for researchers to perform future studies to further identify and explain the degree to which certain government's dynamic capabilities are for fostering mission-oriented research. As discussed above, it is can also be understood that over-exploitation of public research by private actors can disrupt mission-oriented innovation and result in innovations that are undesirable or unfit to address greater societal challenges (i.e., which are more commercialized and focused on generating capital). Therefore, the results of this thesis can also be used to develop future studies to understand the degree to which governments should allow private exploitation of basic research. Additionally, this study in focused on identifying the extent of private participation in European mission-oriented research. Researchers and scientists can conduct similar research to identify the extent of private as well as public participation in other nations worldwide.

Additionally, the theory on the dynamics of innovation discusses that the fragmentation of knowledge and resources across nations does affect the innovation activities across these very nations. This thesis identifies the extent of private participation in European economies and different societal challenges through an exploratory analysis of the CORDIS database. By doing so, this study supports the theory mentioned above by identifying that geographical proximity does indeed allow for fostering new knowledge and skills, which can be used to benefit the innovation in the entire European Union. Using these results, researchers can identify what factors drive tacit knowledge and skill sharing across the European member states, and also to what degree they are shared across these countries or sectors or technological systems.

The literature on the transition studies states that both incumbent firms and SMEs are essential for addressing contemporary societal challenges because addressing these challenges requires an abundance of resources and new competencies to develop desirable innovations. This study supports the theory and contributes to this literature as it identifies that SMEs and startups do indeed require to collaborate for creating desirable innovations. The results obtained in this study can provide a foundation for scientists and researchers to conduct future research for understanding the factors that drive collaborations between incumbents and SMEs. Additionally, based on the literature it is understood that the Horizon 2020 framework programme promotes and supports innovation in SMEs and startups. Further studies can be used to identify what factors provided by the Horizon 2020 framework programme support SME participation and how these can be further improvised or steered for more effective participation and growth of such SMEs.

6.2 Practical Contribution

The central objective of this thesis is to identify the extent of private participation in European mission-oriented research. Based on the obtained results and the discussion in the previous section has provided deeper insights into the extent of private participation across the various European member states as well as across different societal challenges selected for this research. Researchers in the field of mission-oriented innovation policies can practically implement the results obtained from this research (along with further research to identify the extent of public participation) to identify the gaps in current policy formulation and improvise upon them. By utilizing the results of this study, researchers can identify multiple factors that affect the extent of private participation and can develop a theoretical framework to identify factors that influence the same. Policy makers can involve researchers in the formulation and implementation of future mission-oriented policies that are specific to a particular set of actors or region/nation or sector or directed towards a specific societal challenge. As mentioned above in the theoretical contributions, policy makers across different nations worldwide can utilize the results of this thesis along with future research to successfully implement suitable mission-oriented innovation in their nations.

As from the section 1.4.1, the main research question is divided into multiple sub-research questions in order to answer the main research question systematically. In order to address the central objective, data from the CORDIS database was analyzed quantitatively. However, this analysis identified certain shortcomings of the CORDIS database. It was observed that the database misses on recording specific fields that would be valuable for steering mission-oriented policy for better understanding the participation of public and private actors. By reflecting on the theory on the dynamics of innovation in different industrial sectors and technologies, the exploratory analysis conducted on the CORDIS database identified that fields regarding the specific technology developed by a mission-oriented initiative and the industrial sector in which the initiative is conducted were missing.

As discussed in section 4.5 and section 5.2, it is concluded that the CORDIS database provides the suitable and necessary information to identify the extent of private participation in European mission-oriented research. Additionally, the exploratory analysis of the CORDIS database provides insights that it can be

utilized for other research, for example to 'identify the extent of public participants'. However, the study also highlights some shortcoming of the database and hence, it has provided a few suggestions for the tracking and maintenance of data regarding the *breakthrough technology* developed in a mission-oriented initiative and the industrial *sector* in which the initiative is conducted. As discussed in the previous section 5, maintaining this data related to *breakthrough technology* developed or *sector* will provide a stronger practical foundation for the CORDIS database to be used for not only developing theory but also to steer policy making for the best suited results as per the nation, region or societal challenge.

6.3 Relevance to Management of Technology

The Management of Technology(MoT) programme at TU Delft prepares students to work as technology managers, scientists or consultants, and entrepreneurs in high-tech, globally competitive businesses or educational setups in a range of industries. Primarily, the MoT programme educates students about the need for using certain technologies in different commercial scenarios, understanding of whether the particular technology will have a suitable impact, and which actors can be of collaborative assistance when developing or procuring the different technologies or theories required. This programme also teaches students that the dynamics of innovation is varies across different organizations, and hence will require very specific solutions for to suit their needs. Lastly, it also provides insights regarding how we can utilize and exploit the tangible and intangible resources in our proximity to the benefit of our organization or for developing the most suitable solution.

In this thesis, the main objective was to identify the extent of private participation in European mission-oriented innovation policies. From the theory on mission-oriented research, it is understood that addressing the greater socio-technical challenges faced worldwide requires dynamic collaborations between public and private actors to develop suitable innovations. The theory also highlights the difference in dynamics of innovation across nations, sectors as well as different societal challenges. Courses in the MoT programme including Technology, Strategy and Entrepreneurship(TSE), Technology Dynamics(TD), Emerging and Breakthrough technologies(EBT) provided a foundation for understanding the differences of dynamics of innovation across nations and sectors, and is therefore relevant to this thesis topic. The course TSE also educates students about different organization types - SMEs and Incumbent, highlights the differences in their innovative efforts and the importance of their collaborative activities for developing both breakthrough as well as competitive products. Theory on mission-oriented research as well as the Horizon 2020 framework programme point out to the need for active collaborations between SMEs and incumbents for successful mission-oriented research. Thus, the contents of the MoT programme provides the necessary theoretical and practical foundation for studying the concept of mission-oriented innovation policies and in identifying the research gaps for the purpose of developing a suitable master's level thesis.

Therefore, the curriculum of the MoT programme provides students with the necessary knowledge and skills to conduct scientific research, and it also aligns with the thesis topic to identify the extent of private participation in European mission-oriented research. Additionally, the programme educates students regarding

research methodologies that are utilized to derive scientifically valid results which can be easily reused by other researchers and scientists to develop follow up research. As a result, it can be concluded that this thesis has utilized the teaching from relevant courses of the MoT programme (including Technology, Strategy and Entrepreneurship(TSE), Technology Dynamics(TD), Emerging and Breakthrough technologies(EBT) and Research methods) in order to obtain desirable results from this thesis. As mentioned above, the results can be used to further develop theoretical frameworks and practically provide policy makers with a foundation to develop suitable results in the future.

7 Conclusion

In the present century, economies worldwide are turning their efforts in research and innovation towards addressing various societal challenges such as climate change, public health care and well-being and adapting to demographic changes. These so called grand challenges are wicked problems which makes them extremely complex and systemic in nature. Addressing them challenges requires numerous public and private actors to collaborate dynamically in order to explore and exploit the available knowledge and resources and add to the entire value chain. Theory on mission-oriented innovation policy provides a systematic framework for public and private actors to work together developing breakthrough innovations that can be used to address these societal challenges. It also emphasizes on the need for system-wide transformations across nations and sectors for successful implementation of these policies. Additionally, in case of the European Union, it is observed that available expertise and tacit knowledge is scattered unevenly across the different member states. As a result, it is not clear to what extent private organizations are currently participating in mission-oriented innovation within this region.

This thesis analyzed the CORDIS database using a descriptive statistical methodology in order to identify the current extent of private participation in mission-oriented research. From the results obtained, it can be concluded that there is a relatively high degree of private participation in European mission-oriented initiatives. Based on the discussions (see 5), it is further understood that larger economies displayed a higher extent of private participants in mission-led research. Therefore, it can be concluded that governments of the larger member states in the European Union possibly possess the right set of the dynamic capabilities better suited to foster mission-led exploration and exploitation, which the governments in smaller economies do not seem to possess. The section 7.1 below, addresses the scope for future research by utilizing the results obtained from this study. It can be additionally concluded that the larger members economies in the European Union have taken advantage of their geographic proximity to benefit from the diversity of knowledge and skills, and increased their efforts in mission-led research and innovation to address various societal challenges.

Aside from the central objective aimed at determining the extent of private participation in European mission-oriented research, this study is also an exploratory analysis of the CORDIS database for identifying the opportunities and challenges faced when analyzing the data available in this repository. Upon descriptively studying the data, it came to notice that the database misses out on maintaining some valuable information that can add to its value. Based on theory, it is understood that identifying the extent of private participation in different sectors and to identify the breakthrough technology that is developed as a result of these initiatives, would add to the quality and accuracy of this research. Therefore, this study highlights the shortcomings of the CORDIS database in terms of missing information regarding the *technology* developed in a mission-oriented initiative and the industrial *sector* in which the initiative is being conducted. In the section 5, it is explained as to why maintaining the two aforementioned fields will benefit researchers and policy makers in steering mission-oriented policies not only within the European Union but also globally. The next section provides a brief detail of the areas for future scientific research.

7.1 Future Scope

The qualitative analysis conducted on the archival data form the CORDIS database yielded results that explicitly highlight the current extent of private participation in European mission-oriented innovation policy. These results can be implemented in follow-up research to further strengthen the theory on mission-oriented research. Future studied could focus on identifying the participation of public actors such as governments, research organizations, and individuals from the general public. Together, the results of these studies would provide a fervent foundation for analyzing and identifying the nuances of *responsible innovation* within mission-oriented research. The results of this thesis can be primarily used to study the *inclusion* dimension of responsible innovation. This study primarily identifies the current extent of private participation in *European* mission-oriented innovation policies. In follow-up research, scientists can conduct studies to identify the extent of public and private participation in other nations world wide. This will also allow for policy makers to develop more suitable methods to implement mission-oriented research to suit the needs of a particular country or sector.

As mentioned above, it is concluded from this thesis that, larger economies have capitalized on the abundant knowledge and skills available within the European Union and spurred mission-led research for addressing societal grand challenges. This indicates the possibility of an existing entrepreneurial state in these larger economies. Future studies can be focused on qualitatively identifying the factors that affect the entrepreneurial state in the European Union and can use it to formulate policies that will be suitable across all of Europe.

The theory section discusses the concepts that provide a foundation for developing a framework for effective mission-oriented innovation policies. In the section 5, the theory in section 2 is compared with the obtained results. By utilizing these results, scientists and researchers can develop causal relationships between the variable to better understand what are the actual factors that affect mission-oriented research across the European Union. For example, it is possible to deduce from the results that the dynamic capabilities of governments in different nations vary. Researchers can utilize the results to identify the factors that influence the dynamic capabilities of governments across different nations and develop a suitable framework to fit different nations or actors. This can facilitate policy makers to utilize the derived causal relationships between variables for developing more suitable mission-oriented policies in order to address the grand challenges faced globally.

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A Appendix

Table 5: Distribution of private actors and SMEs across top 12 European Economies

Country	No. of projects with Pvt actors	Total no. of projects	No. of private actors	No. of projects with SMEs	Subtotal of projects with SMEs	No. of SMEs
Spain	1409	2229	2481	989	1082	1269
Italy	1372	2108	2435	946	1013	1254
Germany	1312	2259	2458	825	933	1008
United Kingdom	1154	2088	1696	791	878	955
France	1116	1788	2107	603	716	752
Netherlands	744	1477	1186	503	553	674
Denmark	640	698	432	223	248	255
Sweden	430	921	603	224	238	253
Austria	430	882	635	242	318	281
Belgium	341	1487	887	357	510	424
Poland	195	571	249	112	132	135
Turkey	98	224	114	46	48	55

Table 6: Distribution of projects with private participants and SMEs in the 8 societal challenges

Societal Challenges	No. of projects with Pvt actors	Total no. of projects	No. of private actors	No. of projects with SMEs	Subtotal of projects with SMEs	No. of SMEs
ENERGY	924	1003	3413	837	878	1698
ENV	431	470	1450	420	430	919
FOOD	510	561	1739	486	514	1126
HEALTH	707	796	1724	639	655	1036
SECURITY	274	289	980	252	258	507
SOCCH-CROSST	38	40	40	38	38	40
SOCIETY	204	324	355	173	207	255
TPT	1222	1373	5582	977	1043	1734

Table 7: Distribution of the number of Projects with Private participants (A)

Societal Challenges	Austria		Belgium		Denmark		France		Germany		Italy	
	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal
ENERGY	95	202	146	312	85	175	221	333	300	489	308	442
ENV	44	92	49	150	30	69	89	173	111	212	146	222
FOOD	34	92	78	193	52	127	135	242	142	264	170	286
HEALTH	30	112	93	234	57	141	147	292	213	396	148	315
SECURITY	25	62	33	106	13	24	88	123	66	145	102	149
SOCCHAL-CROSST	2	3	1	3	4	4	10	12	5	6	3	4
SOCIETY	17	79	24	106	9	52	24	123	35	168	51	168
TPT	183	244	218	392	93	110	413	530	451	615	456	552

Table 8: Distribution of the number of Projects with Private participants (B)

Societal Challenges	Netherlands		Poland		Spain		Sweden		Turkey		United Kingdom	
	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal	Projects with Private participants	Subtotal
ENERGY	174	271	53	113	316	469	94	151	20	45	230	337
ENV	81	158	18	69	171	243	40	114	13	32	124	210
FOOD	99	218	23	88	208	336	37	119	15	38	134	244
HEALTH	141	316	18	60	157	326	78	193	8	20	189	416
SECURITY	39	92	22	60	114	158	13	48	4	16	106	163
SOCCHAL-CROSST	2	2	2	3	4	5	3	4	0	0	2	2
SOCIETY	17	97	4	63	47	136	8	51	9	32	43	178
TPT	197	340	55	125	401	585	158	248	30	43	337	535

Table 9: Distribution of the number of Projects with SMEs (A)

Societal Challenges	Austria		Belgium		Denmark		France		Germany		Italy	
	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal
ENERGY	70	88	86	112	57	71	121	128	204	238	205	225
ENV	34	34	37	45	27	29	61	66	82	107	123	128
FOOD	26	39	56	80	35	41	84	116	144	154	114	134
HEALTH	22	23	52	59	33	34	91	97	158	161	91	97
SECURITY	22	23	20	28	9	9	38	42	42	45	66	68
SOCCH-CROSST	2	2	2	2	4	4	10	10	5	5	3	3
SOCIETY	14	17	17	30	7	9	19	26	22	31	37	48
TPT	52	92	91	156	52	52	182	234	200	217	281	298

Table 10: Distribution of the number of Projects with SMEs (B)

Societal Challenges	Netherlands		Poland		Spain		Sweden		Turkey		United Kingdom	
	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal	Projects with SMEs	Subtotal
ENERGY	115	119	23	32	241	261	57	66	8	11	165	199
ENV	60	63	10	15	148	153	27	28	8	8	102	114
FOOD	81	95	15	15	169	194	17	18	8	9	108	131
HEALTH	108	117	12	12	127	136	56	56	6	6	133	144
SECURITY	27	30	20	22	64	68	11	13	3	3	87	89
SOCCH-CROSST	2	2	2	2	4	4	3	3	0	0	2	2
SOCIETY	14	19	4	7	37	43	6	8	6	6	36	45
TPT	99	112	26	27	205	231	47	51	9	9	162	168

Pranav_DA_Prop_Country.py > ...

```python
#! /usr/bin/env python #Path for pyhton environment
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns

df = pd.read_excel(
    "/Users/pranavnair/Desktop/MOT/Thesis/Dataset_CORDIS/Working/Main/GL_Data/Final Lists Proportion.xlsx",sheet_name="Prop Country"
)  # Read CSV File
# Remove First Column as it contains name of the projects
df = df.drop(df.columns[0], axis=1) #exclude df.column[0], axis=1 excludes column, while df.column[0}, axis=0 will remove rows
df = df.replace("-", np.nan)  # Replace "-" with NAN (not a number) in all columns
df = df.astype(float)  # Convert all values to float
# Sort data bassed on median values in descending order
sorted_index = df.median().sort_values(ascending=False).index
df_sorted = df[sorted_index]  # Create a new data of sorted values
sns.boxplot(data=df_sorted, showmeans=True, meanprops={"marker":"o", "markerfacecolor":"black", "markeredgecolor":"black", "markersize":"5"})
print(df_sorted)
print(df_sorted.count())
print(sorted_index)
plt.xlabel("Countries", size=12), plt.ylabel(
    "Ratio (Private actors to Total no. of actors)", size=12
), plt.grid(True), plt.title(
    "Country-wise Proportion of private actors in Mission-oriented projects"
), plt.show()
```

Figure 7: Python - Proportion of Private actors in Mission-oriented Initiatives per Country

Pranav_DA_Prop_SMEs_Country.py > ...

```
 /usr/bin/env python #Path for pyhton environment
port pandas as pd
port matplotlib.pyplot as plt
port numpy as np
port seaborn as sns

 = pd.read_excel(
  "/Users/pranavnair/Desktop/MOT/Thesis/Dataset_CORDIS/Working/Main/GL_Data/Final Lists Proportion.xlsx",sheet_name="Prop SMEs Country"
 # Read CSV File
Remove First Column as it contains name of the projects
 = df.drop(df.columns[0], axis=1) #exclude df.column[0], axis=1 excludes column, while df.column[0}, axis=0 will remove rows
 = df.replace("-", np.nan)  # Replace "-" with NAN (not a number) in all columns
 = df.astype(float)  # Convert all values to float
Sort data bassed on median values in descending order
rted_index = df.median().sort_values(ascending=False).index
_sorted = df[sorted_index]  # Create a new data of sorted values
s.boxplot(data=df_sorted, showmeans=True, meanprops={"marker":"o", "markerfacecolor":"black", "markeredgecolor":"black", "markersize":"5"})
int(df_sorted)
int(df_sorted.count())
int(sorted_index)
t.xlabel("Countries", size=12), plt.ylabel(
  "Ratio (Private SMEs to Total no. of Private actors)", size=12
 plt.grid(True), plt.title(
  "Country-wise Proportion of private SMEs in Mission-oriented projects"
 plt.show()

```

Figure 8: Python - Proportion of SMEs in Mission-oriented Initiatives per Country

Pranav_DA_Prop_Socch.py > ...

```python
#! /usr/bin/env python #Path for pyhton environment
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns

df = pd.read_excel(
    "/Users/pranavnair/Desktop/MOT/Thesis/Dataset_CORDIS/Working/Main/GL_Data/Final Lists Proportion.xlsx",sheet_name="Prop Socch"
)  # Read CSV File
# Remove First Column as it contains name of the projects
df = df.drop(df.columns[0], axis=1) #exclude df.column[0], axis=1 excludes column, while df.column[0}, axis=0 will remove rows
df = df.replace("-", np.nan)  # Replace "-" with NAN (not a number) in all columns
df = df.astype(float)  # Convert all values to float
# Sort data bassed on median values in descending order
sorted_index = df.median().sort_values(ascending=False).index
df_sorted = df[sorted_index]  # Create a new data of sorted values
sns.boxplot(data=df_sorted, showmeans=True, meanprops={"marker":"o", "markerfacecolor":"black", "markeredgecolor":"black", "markersize":"5"})
print(df_sorted)
print(df_sorted.count())
print(sorted_index)
plt.xlabel("Societal Challenge", size=12), plt.ylabel(
    "Ratio (Private actors to Total no. of actors)", size=12
), plt.grid(True), plt.title(
    "Societal Challenge-wise Proportion of private actors Mission-oriented projects"
), plt.show()

```

Figure 9: Python Code - Proportion of Private actors in Mission-oriented Initiatives per Societal Challenge

Pranav_DA_Prop_SMEs_Socch.py > ...

```
 /usr/bin/env python #Path for pyhton environment
port pandas as pd
port matplotlib.pyplot as plt
port numpy as np
port seaborn as sns

 = pd.read_excel(
  "/Users/pranavnair/Desktop/MOT/Thesis/Dataset_CORDIS/Working/Main/GL_Data/Final Lists Proportion.xlsx",sheet_name="Prop SMEs Socch"
 # Read CSV File
Remove First Column as it contains name of the projects
 = df.drop(df.columns[0], axis=1) #exclude df.column[0], axis=1 excludes column, while df.column[0}, axis=0 will remove rows
 = df.replace("-", np.nan)  # Replace "-" with NAN (not a number) in all columns
 = df.astype(float)  # Convert all values to float
Sort data bassed on median values in descending order
rted_index = df.median().sort_values(ascending=False).index
_sorted = df[sorted_index]  # Create a new data of sorted values
s.boxplot(data=df_sorted, showmeans=True, meanprops={"marker":"o", "markerfacecolor":"black", "markeredgecolor":"black", "markersize":"5"})
int(df_sorted)
int(df_sorted.count())
int(sorted_index)
t.xlabel("Societal Challenge", size=12), plt.ylabel(
  "Ratio (Private SMEs to Total no. of Private actors)", size=12
 plt.grid(True), plt.title(
  "Societal Challenge-wise Proportion of private SMEs Mission-oriented projects"
 plt.show()

```

Figure 10: Python Code - Proportion of Private SMEs in Mission-oriented Initiatives per Societal Challenge

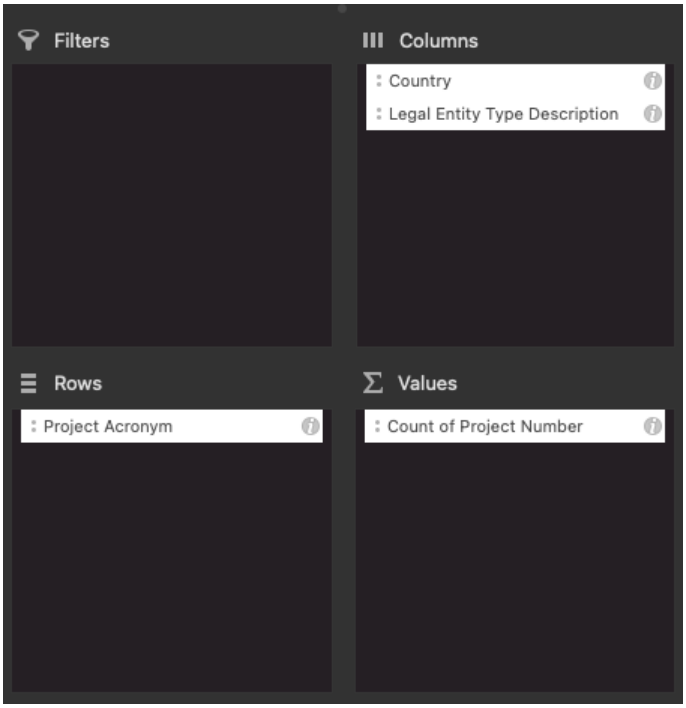

Figure 11: Pivot table design for Sub-research Question 1

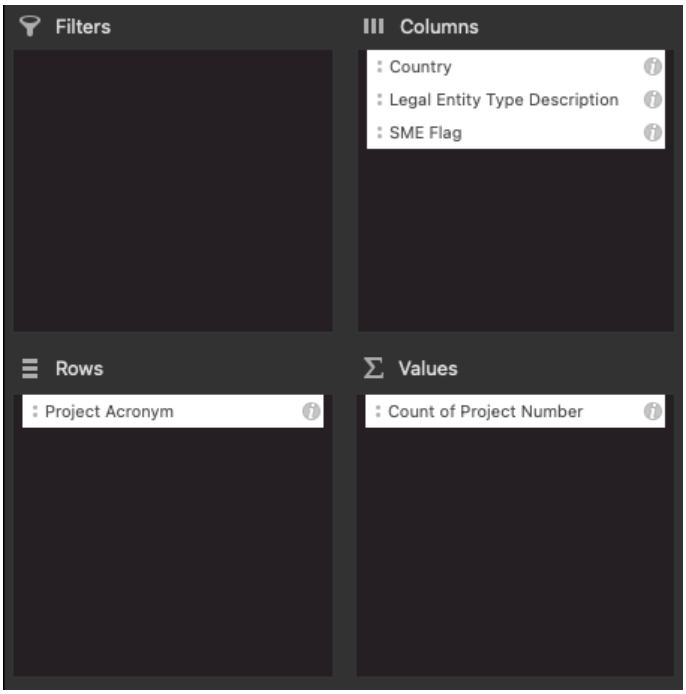

Figure 12: Pivot table design for Sub-research Question 1

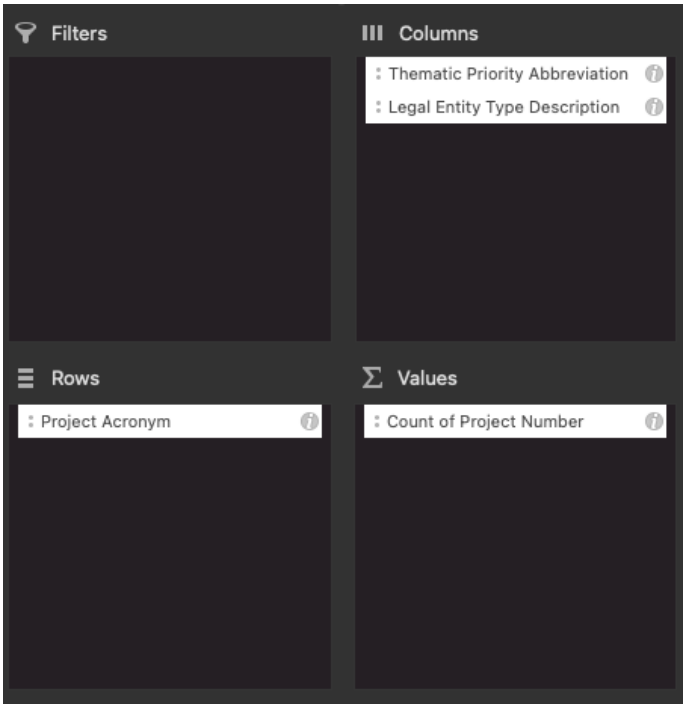

Figure 13: Pivot table design for Sub-research Question 1

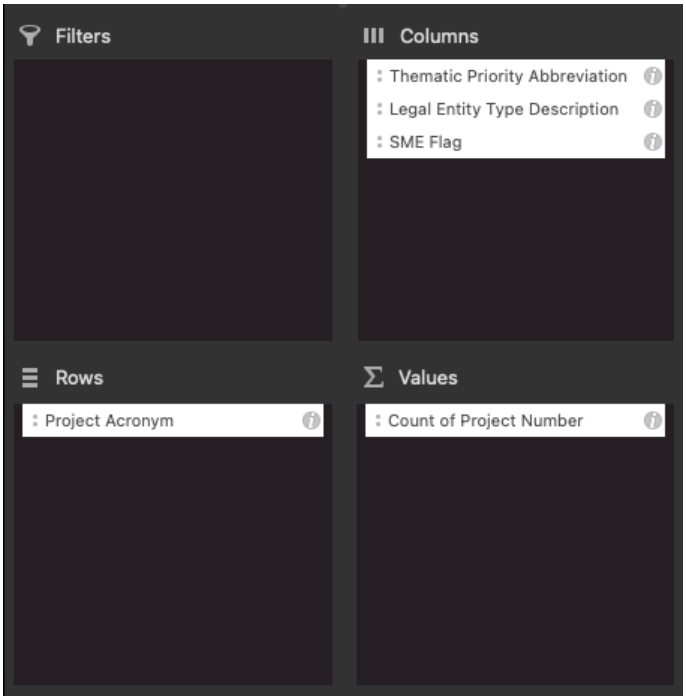

Figure 14: Pivot table design for Sub-research Question 1