

**Influencing factors within SBIR-based innovation research in  
public institutions**

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## *Abstract*

This research aims to provide an overview of factors that influence SBIR-based procedures. This means that this research tries to find new influencing factors for future dedicated research and provide an overview for scholars and practitioners. This overview is helpful for governments when making policy decisions on how to design an SBIR-based program and what factors need to be taken into account. This was done by making an overview of factors from previous research into SBIR procedures and other governmental innovation research literature. Then expert interviews were conducted and secondary data sources such as program evaluations were analysed, these findings were summarised in an overview. The overview from the results is largely different from the overview from previous literature, largely due to this thesis's general and qualitative nature. The findings show that firstly, the whole procedure should focus on accessibility, clarity and informality. Secondly, a new trend has been identified, which is that organisations that perform an SBIR-based procedure are starting to focus more on the external environment, for example, by analysing in which innovations venture capital money is invested. Thirdly, new research areas have been found in (1) the composition of the selection committee. Four expert categories have been found but there are no clear results on the effectiveness of different experts in different situations. This is reflected in new research area (2) which is the finding that an SBIR-based procedure can follow two distinct goals: pursuing an innovation for societal gain or solving a problem within the organisation. The impact of this difference is hinted towards in the composition of the selection committee, but this is for future research.

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## 1. Introduction

Innovation is important for governments because it provides solutions for problems where there is no existing solution on the market yet. With this goal there are societal benefits because societal problems can be solved, and there are economic benefits because new innovations can stimulate an economy. This thesis is in cooperation with the Dutch Ministry of Defence (DMoD), as they want to improve in supporting innovation and they need solutions for problems. They are in the process of creating a Small Business Innovation Research (SBIR) based procedure, which they are calling Strategic Defence Innovation Research (SDIR), and they want to know how to design this procedure and are therefore interested in factors that influence the success of these sorts of procedures.

SBIR is a promising means for governments to accelerate innovation and support high-technology small and medium-sized enterprises (SMEs)(Lerner, 1999). The key difference with private funding is that the SBIR program plays a vital role in supporting technological developments that may not have been developed without subsidy. Therefore, the key function of the SBIR program is to fund good proposals that may not have received sufficient funds from other funding sources (Wallsten, 2000). The original SBIR program was established by the U.S. Congress in 1982 as a response to the reduction of national competitiveness in the global markets (Audretsch, Weigand, et al., 2002). An SBIR-based procedure consists of three phases. Phase I is where the tender is put out, projects are selected, and the selected companies perform feasibility research. Phase II is the creation of a prototype, and phase III is the commercialisation of the project (Audretsch, Link, et al., 2002). Nowadays, the SBIR program or variations of this program with roughly the same structure of phase I, phase II and phase III are being used by many different agencies in the U.S (Wessner, 2009), outside of the U.S. by other governments (Inoue & Yamaguchi, 2017) and not only targeted towards SMEs but also larger companies (Tredgett & Coad, 2013).

Research has shown that SBIR programs succeed in getting organisations to innovate in areas they would not have due to a lack of resources (Audretsch, Link, et al., 2002; Link & Ruhm, 2009). However, current research on SBIR has been primarily focused on singular factors, such as the amount of funding and support programs. These may have an effect on a successful outcome, which is almost always the eventual commercialisation of an innovation. Most research on factors influencing SBIR focuses on the role of private venture capital. This thesis identified three areas where there are factors: finance, strategic R&D and support. Finance is about the size of the award amount in money, and having investments from private capital sources is positively influenced with the chance of succeeding into commercialisation (Link & Ruhm, 2009; Link & Scott, 2010; Toole & Turvey, 2009). Being part of an SBIR program as an organisation helps with obtaining this funding as it signals to investors that there is a market for this innovation (Lerner, 1999). Strategic R&D is about investing resources in projects that align with the strategic goal of the organisation, and this is for example about factors that can be taken into account when tendering and selecting projects. The incorporation of universities within the innovation project (Link & Ruhm, 2009; Siegel & Wessner, 2012) is an example of this, because this involvement signals a high amount of scientific potential for the innovation. Supporting companies with marketing to investors (Cooper, 2003) is an example of support, this is about activities a government agency can organise for companies in their SBIR-based project that help them succeed.

There is currently no comprehensive overview of factors that positively or negatively influence the outcome of SBIR-based procedures for governments. This research aims to make such an overview of factors found within the literature and during interviews with relevant experts. This means that this research tries to find new influencing factors for future dedicated research and provide an overview for scholars. This research is helpful

for governments when making policy decisions on how to design an SBIR-based program and to guide government employees on what to do and what not to do when working with SBIR.

The research questions of this thesis are: What are the influencing factors within SBIR-based innovation research in public institutions? What are the implications of this for the SBIR-based program from the DMOd?

## *2. Literature review*

### *2.1 SBIR-based procedures in policy and practice*

The Small Business Innovation Research (SBIR) procedure is the result of a successful test at the National Science Foundation (NSF), this procedure was tested to stimulate small businesses in 1977 (Audretsch, Weigand, et al., 2002). This eventually led to the approval of the Small Business Innovation Act in 1982. This meant that all government departments with a research program over a certain value had to establish a SBIR program, and this led to a quick acceleration of this program in the United States. This 1982 act outlined 4 objectives for the SBIR program: "1. To stimulate technological innovation. 2. To use small business to meet Federal research and development needs. 3. To foster and encourage participation by minority and disadvantaged persons in technological innovation. 4. To increase private sector commercialisation of innovations derived from federal research and development" (Audretsch, Link, et al., 2002, p. 146). Nowadays, the SBIR procedure is also being used in other countries in adapted forms to adhere to local or regional preferences or regulations (Inoue & Yamaguchi, 2017) and it isn't exclusively being used for small and medium-sized companies (Tredgett & Coad, 2013).

Because there are differences between most SBIR programs in different agencies and/or governments, this thesis speaks of SBIR-based procedures. The foundation of the SBIR procedure is that it consists of 3 phases. Phase I consists of the initial exploration and assessment of the feasibility of innovative ideas. Small businesses compete for funding to conduct preliminary research and feasibility studies to evaluate the technical feasibility of their proposed projects. When a company is selected for phase I, it can conduct a feasibility study of its project financed entirely or partially by the SBIR program, depending on the total costs and the award amount (Lerner, 1999). In phase II, selected companies which successfully completed the feasibility study get funding to develop and produce a prototype of their project. The duration and the amount of funding are more substantial in comparison with the first phase (Audretsch, Link, et al., 2002). Phase III is the goal of the SBIR procedure, as it aims to facilitate private commercialisation (Link & Scott, 2009). In this phase, the innovation is commercialised and available for purchase. To bridge the gap between phases II and III, companies almost always need to rely on private venture capital because normally there is no SBIR funding in part III (Toole & Czarnitzki, 2007). One important thing to note is that phase III within European countries is not a part of the official program, as the companies usually obtain those contracts through a standard tendering procedure in compliance with the European procurement legislation (Tredgett & Coad, 2013).

The SBIR procedure overall is deemed a success within the literature, even though there are also critical notes. The SBIR program promotes technology-based innovation and addresses market failures, particularly in areas aligned with governmental procurement interests (Martin & Scott, 2000), has employability and economic benefits (Link & Scott, 2012), plays a crucial part in the USA in funding SME's and innovation (Inoue & Yamaguchi, 2017) and proved fundamental in important innovations such as cancer treatment methods and other clinical solutions (Prasanna et al., 2015). However, many innovations still fail to continue into the commercialisation phase (Link & Wright, 2015). Link & Scott (2009) found in a sample of 762 observations that the average commercialisation rate is 0.47 in that specific program, with a high standard deviation, which could indicate much room for improvement within the program. The current literature has not thoroughly analysed

which factors have an effect on the outcome. Multiple separate factors have been researched in the past, but there has been no attempt to find new factors. That is why it is relevant to investigate which factors influence the outcome of an SBIR-based procedure.

The factors found within the literature can be classified into three categories, namely finance-related, strategic R&D and support related factors. These factors will be further explained in their respective parts, and they will be used throughout the whole thesis to maintain structure and consistency. A fourth category is included in the literature review, namely factors from other related research areas. Other related research areas that also deal with innovation could provide interesting factors that haven't been researched in a SBIR context yet, but could have an effect. These factors can help with finding new factors in an SBIR context and therefore they are included in this literature review.

## *2.2 Finance-related factors*

The literature describes multiple factors that contribute negatively or positively to the chance of an SBIR-based procedure being successful, while the definition of success changes. One of the relevant identified categories is finance. Whether the amount of money being given by the SBIR program is correlated with eventual commercialisation is unclear in the literature. Studies like Howell (2017) indicate that, especially in the early stages of development, the amount of money allocated can be important as it enables technologies to be developed, and this effect is even more substantial for more financially constrained companies. Howell (2017) states that: "This study's main policy implication is that the SBIR program—and perhaps similar programs—could achieve better outcomes by reallocating money (i) from larger, later stage grants to more numerous small, early-stage grants" (p.3). However, the research from Toole & Turvey (2009) remains more inconclusive and says for example about phase I funding that "Previous research suggests the amount of Phase I investment increases the likelihood firms will progress into Phase II ... Our results show the amount of Phase I investment has a significant leveraging effect on follow-on venture capital. If the investment criteria used by other external financing agents are similar to those of venture capitalists, increasing the Phase I limit may improve commercialisation outcomes. At the very least, the legislative limit on Phase I SBIR funds deserves further research." (p.56). This means that phase I funding could increase the chances of commercialisation, but not directly. They indicate a mediator effect in the involvement of Venture Capital (VC).

Other research is not focussed on a specific phase and found that the award amount negatively correlates with project failure after conducting quantitative research in a database (Link & Wright, 2015). However, other studies mention no correlation between the amount of money offered and the actual chance of commercialisation (Link & Ruhm, 2009). That there is no direct correlation may not mean there is no indirect correlation, but this remains unclear in these studies. Depending on the objective and what success is, it is also possible that increasing phase II funding could be helpful. There is also research that indicates that increasing phase II funding is positive for steering innovation. Steering innovation is deciding in which direction an innovation should develop and what it should be able to do, for example when an organisation wants a certain feature in an innovation which they need. In instances where steering innovation towards a desired outcome is the objective, increasing phase II may be a way to achieve this (Selviaridis, 2020).

Venture Capital (VC) money was already mentioned, and it is clear that the involvement of external money outside of the SBIR program is positively related to the chance of success. Companies in regions with considerable VC activity have grown quicker, and participants argue that participating in an SBIR program has a positive signalling function towards VC investors (Lerner, 1999). Link & Ruhm (2009) mention that besides the positive correlation of VC investments, an investment with additional funding for the project from the owner or business itself has a comparable or even more significant positive effect on the chance of commercialisation.

This is because VC funding is deemed the best way to finance new high-tech companies, with considerable hard support such as funding and soft support, for example entrepreneurial advice, from the funder (Bottazzi & Da Rin, 2002). However, SBIR and VC do work together and are generally not competitors according to Toole & Czarnitzki (2005), they looked into the biomedical world and found that SBIR appeared to attract more biomedical entrepreneurs, despite bigger VC investments.

### *2.3 Strategic R&D factors*

Strategic R&D in a business or government setting is the deliberate allocation of resources to R&D projects to make sure they align with the organisation's strategic goals (Choi & Park, 2016). For an SBIR-based context, this means that everything from the writing of tenders, selection of projects, the coordination and more should be focused on strategic R&D. When looking at the writing of tenders and the selection of projects, there are a couple of relevant factors that could be included in this process as it increases the chance of success. Multiple studies confirmed universities' involvement as a positive factor in the SBIR procedure (Siegel & Wessner, 2012). Besides having value to the company and the SBIR agency, it is found that having academic involvement also increases the number of scientific publications published by the awardees. Therefore, this involvement has an added value to society (Audretsch et al., 2019).

As there is a limited amount of literature on influencing factors it is interesting to also take into account the more global academic fields of Research & Development (R&D) and the private business area such as, for example, innovation competitions or within the government area with pre-commercial procurement (PCP). Research about the success of R&D projects in companies found that several factors positively correlate with the chance of succeeding. Among them are the culture within the firm, the experience they have with innovation, the multi-disciplinary character of the R&D team, the explicit recognition of the collective character of the innovation process (Panne et al., 2011) and the project manager at the company having proper certifications (Müller & Turner, 2007). These factors and some more are also identified by Iossa et al. (2018), they mentioned that within PCP there are projects that "may be undermined by lack of appropriate skills, incentives and competencies within the public sector, as also suggested by recent empirical work on the impact of procurer competency on procurement outcomes. Lack of skills, incentives and cooperation may result in inappropriately designed tenders and contracts, with delays, cost increases, and poor results. Compared to traditional procurement practices, innovation-oriented public procurement makes capacity building even more central to the success of the procurement process." (p.17). They furthermore mention that a multi-disciplinary approach with a variety of specialties involved is beneficial in order to "reshape many procurement offices currently too focused on ensuring the correct application of the law, rather than on the strategic design and efficient use of public procurement." (p.17).

### *2.4 Support related factors*

Support is about activities the government agency can include in the SBIR-based program to stimulate the projects. A study by Cooper (2003) saw that: "For some SBIR firms, Phase III can come too soon... These firms, while having top quality technological innovations, often require business assistance to move them to a point where private markets – venture and angel capital – are willing to invest in them. While the SBIR program supports the invention and early R&D phases, effectively increasing the supply of small businesses seeking to develop new markets for their innovations, it does not currently provide the coordinated and direct business assistance needed to help these projects realise their commercial potential... A recent study of SBIR awardees found that insufficient funding was the primary reason that SBIR projects were discontinued after Phase II. The study found that the lack of market knowledge or marketing skills was the most frequently cited obstacle to commercialisation. This was corroborated recently by a new survey of SBIR firms which shows that 63 percent of SBIR firms say they need business assistance to commercialise their new technology." (p. 148). This means



that specifically in phase II, focusing on not only the product but also the soft skills of the business owner could increase their chances of succeeding in commercialising.

### *2.5 Factors from SBIR related research areas*

Steering innovation as a government has become even more important recently because "governments have recognized they may need to align social and environmental challenges better with innovation objectives. Climate change, reduction of equality, poverty and pollution have been transformed into challenges and opportunities for science, technology and innovation policy. Through initiatives such as Horizon 2020, the EU expects innovation to address a number of well-chosen societal challenges and for example contribute to a transition to low carbon and inclusive economy." (Schot & Steinmueller, 2018, p. 1561). However, the objective to steer innovation as a government is not new, the SBIR procedure was created in 1982 (Audretsch, Weigand, et al., 2002) and there are also other procedures with the same purpose of steering and stimulating innovation as a government. Two examples are the innovation contest (Adamczyk et al., 2012) and Pre-Commercial Procurement (PCP) (Edquist & Zabala-Iturriagoitia, 2015). Because these innovation procedures were created with the same goal as SBIR, it is interesting to take a look at factors that have been found in their respective research areas.

Innovation contests is an open innovation method where an organisation posts a challenge and promises a reward to attract multiple companies to develop solutions to solve the challenge (Adamczyk et al., 2012). Research by Vrolijk et al. (2021) into an innovation contest by NASA investigated characteristics of this innovation contest that help in achieving eventual success and they are, among others, the network possibilities that it provides with other companies and "getting diverse and early input on the problem's requirements enables the later technology-related benefits... Striking a balance between these two increased the likelihood of successful development by solvers and useful solutions for the NASA SMEs. These early interactions between the seeker and the outsiders also allowed for informal conversations about future needs, technological and market directions, and collaboration opportunities—all under the guise of the contest." (p. 36). They also addressed factors due to their case study being in a government situation "Our case study focused on a government program that specialises in running complex innovation contests. First, a government context can better facilitate information sharing because of a reduced emphasis on intellectual property and competitive advantages. In our case, NASA SMEs readily shared information with solvers and external experts when it did not adversely affect the contest. In addition, the complex nature of the problem likely attracted more large teams, whose members had more applicable experience" (p.37). These factors: network possibilities, early input from participants and open information sharing are interesting to take into account when looking at SBIR. These factors, especially in a governmental context, can also be confirmed by other research such as by Pihlajamaa & Merisalo (2021) who found that early input and information sharing is important in these procedures.

Another scientific area that may have interesting insights for SBIR-based procedures is the field of Pre-Commercial Procurement (PCP). PCP is a strategic instrument introduced by the European Commission in 2006 to stimulate innovation and address societal challenges. It involves public sector organisations procuring research and development services, typically up to the prototype or first test production stages (Edquist & Zabala-Iturriagoitia, 2015). Research by Selviaridis (2020) in the academic area of PCP used the UK Small Business Research Initiative (SBRI) for a case study as an example of PCP, and this is an SBIR-based procedure. Despite the fact that the SBRI is also open for large companies, this research mentions that: "Through securing government R&D contracts and carrying out SBRI-funded R&D projects, small firms get access to relevant innovation ecosystems, build up their knowledge and capabilities and explore possible routes to market for their products under development." (p.22) However, he also mentions certain obstacles that participants are

experiencing. One of them is the need to have the by a government requested technologies be part of a broader national innovation strategy, as this would improve continuity and provide more structure. Furthermore, more interactions between the funded firms, public organisations and the end-user(s) are seen as a way to improve. Within the government itself, it is often experienced that there is a lack of coordination between different areas such as R&D and procurement, and that there is a gap between the completion of phase II and full commercialisation. Lastly he mentions that there should be attempts to shift conservative attitudes from civil servants and procurement professionals towards a more innovative mindset where there is more room for taking risks.

<i>Factor category</i>	<i>Factor</i>	<i>Based on</i>
Finance	More phase I instead of phase II financing is positive for attracting VC and successful exits	(Howell, 2017; Toole & Turvey, 2009)
	Higher total SBIR award size is positive for avoiding project failure	(Link & Wright, 2015)
	No correlation between more SBIR funding and commercialisation	(Link & Ruhm, 2009)
	Funding from other sources than the SBIR program is positive for commercialisation rate	(Link & Ruhm, 2009; Lerner, 1999; Bottazzi & Da Rin, 2002)
	Increasing phase II funding is positive for steering innovation	(Selviaridis, 2020)
Strategic R&D	Prior firm R&D experience is positive for avoiding project failure	(Link & Wright, 2015; (Panne et al., 2011)
	Larger firm size is positive for avoiding project failure	(Link & Wright, 2015)
	Involvement from universities is positive for increasing commercialisation rates	(Link & Ruhm, 2009; Siegel & Wessner, 2012; Audretsch et al., 2019; Toole & Czarnitzki, 2007)
	Certified project managers at the firm is positive for meeting project objectives	(Müller & Turner, 2007)
	Multi-disciplinary character of the R&D is positive for the technological and commercial viability of an innovation	(Panne et al., 2011)
	Early input from SBIR participants into the creation of a tender to successfully source new innovations	(Vrolijk et al., 2021; Pihlajamaa & Merisalo, 2021)
	More coordination and cooperation within the government to influence the market and their innovation incentives	(Selviaridis, 2020; Iossa et al., 2018)
	Make projects fit into a broader national innovation program to make sure that the innovation is relevant	(Selviaridis, 2020)
	Public servants need to have the right skills and incentives to foster an innovative mindset. This is required to aid in developing innovative solutions.	(Iossa et al., 2018)
Support	Support program to aid with market knowledge and marketing skills	(Cooper, 2003)

	Providing network possibilities is important to provide additional benefits that help in innovation	(Vrolijk et al., 2021)
	Open information sharing between firms, government and end-users is beneficial to address systemic failures in innovation	(Vrolijk et al., 2021; Selviaridis, 2020)

Table 1. Factors found in the literature

### 3. Methodology

#### 3.1 Research design

To answer the research questions this thesis will explore new potential factors that haven't been found in the academic literature until now and verify past research when already known factors are found. These findings will be bundled to create a comprehensive overview of relevant factors to consider when creating an SBIR-based procedure and include topics for further research. The nature of this research is exploratory and explanatory. The exploratory nature is due to the goal of identifying relevant factors that have not been identified yet in the literature, and the explanatory nature is due to the goal of combining previous research and new findings into one comprehensive overview (Saunders et al., 2019). For this thesis expert interviews are conducted and secondary data sources are used to supplement the interviews. An overview of the literature that is being used for further analysis is provided in appendix A. This appendix is also the basis for table 1 in which the categories are mentioned with their respective relevant factors and the academic source. The overview in table 1 and the structure it has with the factor categories it has is used to create the interview guide for the expert interviews and to maintain a clear structure throughout the whole thesis.

#### 3.2 Expert and secondary data source selection

The unit of analysis in this thesis is SBIR-based procedures and the factors contributing to the failure or successful completion of the procedure from a governmental perspective. The units of observation chosen for this respective unit of analysis are expert practitioners due to their experience with creating and performing these procedures. This aligns with the definition of suitable experts for expert interviews, which is that an expert is someone 'who is responsible in some way or another for the development, implementation, or monitoring of a problem or who has privileged access to information about people or decision processes' (Meuser & Nagel, 1991, p. 442, translation by Froschauer & Lueger, 2009) The selection and invitation of interviewees is done in cooperation with the DMO, this is done to get more and easier access to interesting interviewees due to their existing network. The emphasis in case selection was on the quality of the expert rather than the number of interviewees, since the validity in expert interviews is overall not found in quantity but in the reliability of the interviewees and the coherence among the experts (Dorussen et al., 2005). An anonymised overview of the selected interviewees is given in table 1. In total 8 experts were interviewed from 6 organisations. To supplement this secondary data is also used, as this is a suitable method to provide additional insights as long as the data selection criteria is specific and the source is credible (Largan & Morris, 2019). Therefore the selected documents are all assessments or evaluations of SBIR-based programs conducted by the governmental organisation that is performing the SBIR-based program. In total 6 publicly available secondary sources were used from 5 organisations, and permission to use these documents was not explicitly requested because in each document there is an explicit statement that academic usage is allowed and these documents are publicly available. These evaluations were selected because they were publicly available, relevant to the topic of SBIR-based procedures, and had been created within the last 10 years. The latter choice was made in an attempt to make sure that the findings are still applicable to the current situation, because

legislation and ways of thinking can change over time. All evaluation that were available within these requirements were used, and an overview of the used secondary sources is given in table 3.

<i>Interview no.</i>	<i>Number of interviewees</i>	<i>Continent</i>	<i>Expertise in SBIR-based procedure</i>	<i>Budget category</i>	<i>Age of SBIR-based procedure</i>
1	1	Europe	Advises on and conducts SBIR-based procedures for others	N.A.	10-25 years
2	1	Europe	Performs an SBIR-based procedure	50-100 million USD	0-5 years
3	2	Europe	Advises on SBIR-based procedures	N.A.	10-25 years
4	1	America	Performs an SBIR-based procedure	150-250 million USD	25-50 years
5	1	America	Performs an SBIR-based procedure	1000-1500 million USD	25-50 years
6	2	Oceania	Performs an SBIR-based procedure	10-50 million USD	0-5 years

*Table 2. An overview of interviewees*

<i>Source no.</i>	<i>Organisation / Country</i>	<i>Goal of the data source</i>	<i>Source</i>
1	Small Business Research Initiative (SBRI) / The United Kingdom	“This note provides insights into the performance of the UK Small Business Research Initiative (SBRI), nearly two decades after its creation, based on selected evaluations and studies. It also provides a brief comparison with the US Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programmes, and highlights key opportunity areas to enhance the impact of UK SBRI.”(p. 2)	(Castaneda-Navarrete & López-Gómez, 2021)
2	Ministerie van Economische Zaken en Klimaat (EZK) / The Netherlands	“An analysis and assessment of the methodology and outcome of SBIR in Dutch policy practice from its introduction in 2005 to 2016. Associated with this objective are the following three main questions: (1) Is SBIR effective; (2) Is the implementation of SBIR efficient?; and (3) What could be improved?” (p. 5)	(Bongers et al., 2017)
3	National Institutes of Health (NIH) / The United States of America	“, the committee analyzed (1) the effectiveness of NIH’s processes and procedures for selecting SBIR and STTR awardees; (2) the effectiveness of NIH’s	(National Academies of Sciences, 2022)

		<p>outreach to increase SBIR and STTR applications from small businesses that are new to the programs, from underrepresented states, and from woman-owned and minority-owned businesses; (3) collaborations between small businesses and research institutions resulting from the programs; and (4) a range of direct economic and health care impacts attributable to the programs.” (p.20)</p>	
4	National Science Foundation (NSF) / The United States of America	<p>“This report focuses on the operation and performance of the SBIR/STTR programs at the National Science Foundation (NSF)..... this study undertook a detailed assessment of the process by which SBIR and STTR awards are made at NSF, a survey of the landscape of awards that have been granted ..... and a detailed quantitative analysis examining the innovation and commercialization outcomes of firms participating in the programs” (National Academies of Sciences, 2023, p. 14)</p>	(National Academies of Sciences, 2016, 2023)
5	U.S. Department of Defense (DoD) / The United States of America	<p>“This study seeks to understand how the DoD SBIR program could work better in addressing the congressional objectives for the SBIR program to stimulate technological innovation, use small businesses to meet federal R&amp;D needs, foster and encourage the participation of socially and economically disadvantaged small businesses, and increase the private sector commercialization of innovations derived from federal R&amp;D. .... an ad hoc NRC committee issued a revised survey of SBIR companies, revisited some case studies and developed new ones, and interviewed agency managers and other stakeholders to provide a second snapshot of the program’s progress toward achieving its legislative goals.” (p. 16)</p>	(National Academies of Sciences, 2014)

Table 3. An overview of the used secondary sources

### 3.3 Data collection

The interviews consisted of semi-structured interviews, due to the goal of being open to unexpected findings (Gill et al., 2008). The interview guide is given below in table 4. This interview guide is divided into different

phases and designed to follow the structure of Table 1 as closely as possible to improve clarity and structure. Every interview was conducted online due to schedule and geographical constraints.

During and after each interview, the interviewer attempted to be agile, meaning that the interviewer was open to changing up the structure of the interview, evaluating each interview, and adjusting the interview guide if necessary (Adams, 2015). This adjusting has been done by adding two questions, about how their program has been improved in the past 10 years and what they still want to improve on. By doing interviews, these questions were found to provide more meaningful answers because some people were hesitant to go into detail about things that didn't go well. These questions were able to provide more information about areas for improvement. Another notable development is that all interviews mentioned the same kinds of experts that were involved in the selection committee; there are four distinct categories. However, the researcher only recognised this after conducting most of the interviews. Therefore it was not possible to collect data about the reason for differences in the composition of the selection committees between different SBIR-based programs. The question whether and how each expert influences the selection committee cannot be answered, but these findings are still included in the thesis for future research. Because this finding didn't fit into any of the factor categories the support factors category was changed to the support and selection committee factors in the findings and discussion. Within the literature review this category is still called support factors because the composition of the selection committee is not discussed.

Before the start of the interviews the interviewer asked the interviewees if they gave consent for the interview to be recorded after giving them information about the purpose of the recording (Klykken, 2021). All of the interviews were recorded. Interviewees were also informed that the interview data, including their identities, will be handled with confidentiality. The content in combination with the identities or anything related to the interviewee was never shared with the DMOd, unless explicit permission was given (Guillemin & Gillam, 2004). Then, the interviewees were given a general introduction about the research, and they were asked to introduce themselves and their roles for more context. After that, the interviewer started with the interview guide and before each new phase, the interviewer defined the factor category. During the interview and afterwards there was room for additional questions to explore interesting questions and dive deeper into certain topics where one's specific expertise may be.

Phase	Purpose	Questions
Finance	Identify relevant factors in the category of finance	<ul style="list-style-type: none"> <li>- How do you determine the appropriate amount of funding for each phase? What factors influence this?</li> <li>- What is the effect of funding amount on the SBIR procedure and its outcome?</li> <li>- What is the role of external investments in SBIR-based procedures?</li> </ul>
Strategic R&D	Identify relevant factors in the category of strategic R&D	<ul style="list-style-type: none"> <li>- Can you describe the process of making a tender for an SBIR-based procedure?</li> <li>- Can you describe how projects are selected? What factors do you look at?</li> <li>- (If applicable) In your experience or expertise, are there factors that positively or negatively impact the chance of a project succeeding that can be used in the selection phase?</li> <li>- Are there according to you factors that support or prevent innovation at the side of the government?</li> </ul>

Support	Identify relevant factors in the category of support	<ul style="list-style-type: none"> <li>- What kind of support do you think is important for companies to successfully complete the procedure?</li> <li>- Are there things the government can do or facilitate in to improve chance of success?</li> </ul>
DMoD specific	Relevant factors specific for the DMoD	<ul style="list-style-type: none"> <li>- The DMoD is trying to bridge phase II and phase III without a new tender, aside from legal factors, what would be factors that can positively or negatively impact this?</li> <li>- Are there factors specific to the DMoD or that industry which they should take into account when setting up an SBIR-based procedure?</li> </ul>
Flexibility	Room for interesting topics and additional topics	<ul style="list-style-type: none"> <li>- Is there anything you want to add, such as topics or relevant factors that haven't been mentioned yet?</li> <li>- How has your program developed over the years?</li> <li>- What are you looking to improve in the future or are you currently improving?</li> </ul>

Table 4. Interview guide

### 3.4 Data analysis

After each interview the recording was transcribed entirely, and the validity of this transcription was checked with the respective interviewees (Creswell & Miller, 2000). This thesis used the method from Miles, M.B, Huberman A.M, & Saldana (2019), roughly consisting of three phases. First, the data needs to be reduced, and in order to do this the transcriptions were coded into relevant factors. Relevant factors already identified in previous literature, as seen in table 1, were identified with pre-determined codes. When new factors, such as early involvement from procurement, were identified a new code was created. Secondly, the data was displayed similarly to table 1 to create a clear overview and make it easier to follow the analysis. The third step is the analysis and interpretation of the data, here the different displays are compared in order to create a conclusion. This analysis creates a clear overview of factors that were found new or reproduced.

For the first step, which is the coding, everything that could be a relevant factor was coded in the interviews and in the secondary data sources. After this step, the factors were separated into the four categories used throughout the thesis, namely finance, strategic R&D, support and DMoD specific factors. Then the factors were analysed and not relevant factors were removed. This was done in cases where the coded factor in fact was not a factor, but more an interesting point quote during the interview. Another situation where this was done is when a factor was just briefly mentioned in one data source. This does not mean that every factor with only one data source was removed, because there could be valuable information in these factors about for example new developments. In these situations the factor has a signalling function or the data point had a strong indication for a certain factor because it was thoroughly discussed in the interview or secondary data source. There were no contradictions between the different interviews and secondary data sources after considering the context.

After the final analysis, it became apparent that the difference in the definition of success between SBIR-based programs is a hidden theme that multiple interviewees have indirectly mentioned. Because this became apparent after the analysis due to indirect mentions there is no specific data collected for this influence, and it is not possible to categorize data based on a SBIR-based program their success definition or goal. This information is still included and discussed in the findings and discussion because it is deemed important information to deal with research limitations. Additionally, indications that the significance of certain factors may differ based on the success definition or goal of an SBIR-based program is relevant for future research into

this topic and highlights the importance of this underlying theme. For validity it is important to note that relevant factors identified with each interview and their respective quotes were sent to the specific interviewee to check if they agree with the interviewers interpretation of their words and if they still agree with their interview statements (Creswell & Miller, 2000). The secondary data sources were analysed using the same method and codes as when analysing the interviews.

4. Results

4.1 General findings

Table 5 presents an overview of each factor category's most notable findings or quotes from each interview. This overview was created to understand the main topics in each interview better because each interviewee focuses on different topics. Due to this reason, some fields are left empty because this category didn't have focus or didn't provide major findings in that interview. The order in which the interviews are mentioned differs from the order in table 2, which listed all interviewees. This is done to ensure anonymity because an industry professional may be able to deduce the identity of a participating organisation from table 2, and therefore by randomizing the order the findings from each interview cannot be linked to an organisation. The findings for the DMoD specific factors are not included because the table would not be readable with four categories, and this specific category was chosen because some interviews did not provide relevant insights for DMoD specific factors.

There are distinct differences between SBIR-based programs, influencing which factors are important. The first difference is the size of the program, not every factor can be implemented when there are budget and staff limitations. This became apparent when analysing the extent of support programs and other ways of supporting the companies within the program, in one case there was a dedicated section of employees tasked with this support program, and in another case there were 2-3 people who had to run the entire SBIR-based program from the beginning till the end. This means there are differences to consider when looking at the size of programs. The second difference is the program's goal, which was seen even before the first interview was conducted. One organization declined to participate because for the DMoD "Success will strongly depend on the ability of the small business to engage with the program officials at the agency to ensure the technology is of interest for eventual procurement.", and the developed technologies within their SBIR-based program "will be sold into the private sector, so the challenges in understanding the market and customer are quite different, and therefore the success factors will be quite different". This difference in goal or success definition; developing for yourself to be a customer or purely societal benefit, is one that has also been briefly mentioned by a couple of interviewees.

	Financial	Strategic R&D	Support and selection committee
1	"It (the funding) really depends on what you want to develop. If you want to do something with ICT you're talking about different numbers than a hardware development. It also depends on the desired end result, is a raw prototype also acceptable for example?"	"The responsible contact person is really important in this, how he goes into working visits and how he behaves. And if he shows the right commitment. That is something that should get more attention in the procedure"	"(Important factors are)Firstly, a good needs assessment before, having clear needs. Knowing the direction you want to go in. Secondly, that you really write a call that translates this need to entrepreneurs. And a good call is often a short call, because in my experience entrepreneurs don't like to read a lot. So a concrete and clear call is more important than a complete call."



2	<p>"I think what we also need to consider when we look at the funding is how mature is the commercial market around it and how mature is the operational market. So the market around it is an element that we need to feed into how much funding we want to put in."</p>	<p>"we need to include more actors here. And that means that we need to incentivize private capital to go into companies that work on ..... challenges. We need to incentivise. primes to work with smaller scale companies"</p>	<p>"So what we did was the selection process we separated completely from the political oversight so meaning it's purely merit based. And basically includes scientific experts. Commercial loops or VCs venture capital experts did assess the so sorry, let me do this again. So we assess a couple of things, technical feasibility of the solution is being proposed that's being done with active scientists and experts from the ..... networks. We assess the commercial viability of the solution together with VCs and the ..... We assess the operational applicability together with experts that are being sent by ....."</p>
3	<p>"Basically, it's a set maximum amount for each phase and then every year the ....., which is sort of the central agency that coordinates all the different agencies, they adjust those levels for inflation."</p>	<p>"Making sure that they're coming in a little bit more well prepared that they're not gonna need to put in five or six applications just to get that initial feedback and fine tune and figure out what the actual best path forward is. For that phase one having a good idea is sort of on the front end of, you know, what problem am I trying to address? Why is that important and what is a meaningful amount of work that's appropriate to be doing at this stage of development, just having a clear idea of what that is on the front end, I think can be very impactful."</p>	<p>"So you'll see a lot of our ..... do provide access to what we call entrepreneurs in residence. So these are people that have experience in investment venture capital, sometimes fundraising, regulatory expertise, kind of all the other things sort of outside of the strict scientific R&amp;D, but are still required for successful commercialization. We think it's important to provide them access to those resources and expertise. And ultimately to help improve the chances of our investment bearing fruit and impacting the market."</p>
4	<p>"We think that (Flexible amounts of funding) will be a challenge because we think it will get quite complex quite quickly. It also provides clarity to agencies who wish to engage in the programme. They know kind of what size of programme and projects they should be targeting, what kind of things are suitable. And it provides kind of clarity to applicants</p>	<p>"we have conversations much early on just to make sure all expectations are understood by the agency as well as the company. And that way our office is able to facilitate any misunderstandings or misconceptions about the programme much early on to do derisk for the long run."</p>	<p>"We appoint an independent expert panel so it's made-up of five representatives and they're all outside government, so they work in places like incubators, accelerators, venture capital funds, research industry, research organisations kind of quite high up in like university innovation units and stuff. So that's kind of all of their backgrounds. So they are used to kind of dealing with the kinds of applicants we get on this programme, of which most are early stage startups. And importantly as well, it kind of like</p>

	as well. So they're, you know, if they engage with the programme, they know kind of what level of funding they might receive if they participate in it."		isolates it from government. So we get an independent kind of perspective as well. So they are responsible for making the final recommendations about who receives funding. So it really is out of government's hands."
5	The interviewee indicated that there are fixed amounts of funding for each phase	"So we're trying to analyse market dynamics because there's a lot happening outside our gate, so we wanna be well informed on where venture funding is going, what technologies are needed where there are gaps because that can then help inform our solicitation. They're also looking at the results of our funding to try to continually improve the way that we make our decisions and how we're informing our customers."	"Additionally, we provide technical and business assistance, so commercialization, patenting as an additional support for firms as we're trying to see them commercially successful and we offer an ..... program which is a customer discovery program that we encourage our firms to consider."
6	"Well, often it is dictated by how much money the client has in our case. You usually have a feasibility study between ... and ....., sometimes slightly lower depending on whether it's ICT or more physical. As for the second phase, so that varies very, very much."	"Then it is nice if you can involve procurement from the start of the project. You tell them we're going to do this project the next three years and in the end you guys are going to get into the picture to actually buy this, so please do this with us and advise where possible. Especially for larger organisations it is important to involve procurement early on"	"We have bad experience with policy officials on committees, so we basically don't do that. Sometimes you can't escape that, but then you try to put enough other experts around it who look a bit wider too than just the pure policy-related"

Table 5. Highlights of the most notable findings or quotes from each interview for each factor category

## 4.2 Factors

### 4.2.1 Financial factors

Interviewees were asked how they decided on how much funding they would allocate to the different phases. There is a clear difference between organisations that base their funding amount on the market characteristics and those who base their funding on their allocated R&D budget and the maximum allowed funding level defined by their respective laws. The latter is most often found in SBIR-based programs within the United States because the funding amounts there are determined by law. SBIR programs there need to have at least a certain percentage of the total budget of the organisation that is conducting the SBIR program. Furthermore, they have set maximum amounts to give to a single company. Having a set amount was also found in a couple of relatively new programs because this is easy to understand for participating companies, but some of them also highlighted that they would like to move to market characteristic-based funding in the future.

Funding based on market characteristics means looking at the characteristics of the market in which the organisation is trying to get an innovation. One example would be the maturity of the market as mentioned by one interviewee, when a market is relatively new there is a chance that producing innovations in this area is

more expensive. One example is artificial intelligence (AI), a new innovation in this area that is currently more expensive to produce than regular software developments. Another way of looking at market characteristics is by looking at the typical cost of an industry according to another, for example the difference between a software development or a hardware development, because hardware developments are often more expensive to make.

Interviewees didn't comment on whether they think their approach is effective. However, an evaluation into the NSF SBIR program came up with the following recommendation: "the programs' rigidity appears to be suited only for limited innovations. The Phase II limit of \$1 million may be sufficient for software development, but other technologies may need larger investments to be derisked before the private sector is willing to step in, and this gap may be too great to be filled by NSF's limited supplemental funding opportunities. The imposition of rigid restrictions on the number and size of awards also lacks the flexibility to encourage more complex innovations that may require multiple inventions before proceeding to the marketplace." (National Academies of Science, 2023, p. 77). Furthermore, two interviewees stated that external investors have to be considered as important because "we can't do this on our own"

#### *4.2.2 Strategic R&D factors*

Many interviewees and evaluations mentioned factors involving the interaction between the SBIR-based procedure participants and the organiser. Firstly, being accessible and not too formal is mentioned as an important factor, because it lowers the barrier for the participant to approach the organiser. Organisers should make sure that they are accessible, reduce formal procedures and bureaucracy and be involved throughout the whole process. For example, the EZK SBIR evaluation has a recommendation: "Avoid further formalisation, as developing innovative solutions and innovation-oriented procurement benefits from some freedom" (p.119). Secondly, having a permanent contact person for participants of the SBIR-based program to approach is often mentioned as an important factor contributing to a successful outcome, the reason for this is in line with the reasoning for the first mentioned factor. Thirdly, creating more clarity about the program and the requirements or characteristics of the desired innovation for companies before the submission of an application is often mentioned as an improvement area or something that companies "positively appreciated".

The first mentioned factor about being accessible and informal and the third factor about clarity can also be closely related, as highlighted by an interviewee who mentioned that "a good call is generally a short call, because entrepreneurs are not going to read a whole lot in my experience. So the call being concrete and clear, is more important than being completely comprehensive". Multiple interviewees mentioned that the expectations about the SBIR-based projects are not always clear and miscommunications could arise where these could have been prevented. This is also why the SBIR evaluation mentioned that "Departments should update and specify upfront, on a fixed and regular basis, the technological areas in which they would like to see projects." (Castaneda-Navarrete & López-Gómez, 2021, p. 11) and an NSF assessment recommends that "NSF should continue to provide early feedback to SBIR/STTR applicants as part of the Project Pitch process and should consider instituting an application assistance program for new applicants." (National Academies of Science, 2023, p. 78)

Providing access to governmental facilities and resources to participating companies is mentioned as a way to 1) Promote cooperation and better understanding between the individuals who require the innovation and those who have to develop it, therefore having more direct communication instead of communicating indirectly and 2) To test the prototype in a real setting. Interviewees also mentioned that an experienced project manager at the company side helps in ensuring a more seamless project, because "You just need someone who understands the tech and the science, but then also understands how to run a project and how to come with

the right attitude to those meetings and be able to do all of that project management stuff in the background to ensure the process is just seamless”.

Several interviewees mentioned that procurement should be involved from an early stage. Because these people are responsible for actually buying this innovation at the end of the SBIR-based procedure, it is mentioned that it is important to take them along from the start. The reason for this is that they can help create a more precise need and identify possible problems that could arise at the end, this way these problems can be dealt with.

Both the evaluations and interviews indicate that the impact of SBIR-based programs is currently not properly measured. Most frequently mentioned is that what happens after a company finishes or leaves the program is not measured. Therefore it is hard to determine what part of a company’s success can be attributed to the SBIR-based procedure. This information is also expected to help assess which parts of the program and procedures are working and to "continually improve the way that we make our decisions and how we're informing our customers.". Another factor regarding analysis is that there is currently a lack of knowledge about the external market and what private capital investors are looking for. The external market is what happens outside the SBIR-based program, for example private investors and their decisions or developments in the industry. One example is that an interviewee mentioned that they are in the process of setting up a business intelligence unit within their SBIR agency, and this unit has, among other things, the task of analysing where venture capital investments are going. The interviewee mentioned that they are doing this because "we don't have that kind of insight at this point, but it's an intention that we do get a feel for that because there are certainly lots of aspects of our investments where private finance should be ready to pick it up, and so this is about trying to figure out how do we understand their interests and what they are funding."

Lastly, interviewees experience having partnerships between companies as a positive factor. However, they also notice that it isn't always reasonable for small companies in a phase I study to have partnerships, therefore this factor isn't viable in every scenario. One interviewee mentioned the importance of partnerships that they “actually saw that right from the very first SBIR. We felt very quickly that you have to work together, because sometimes you see a certain company that does have certain knowledge in house, but never all the knowledge, especially if you address the smaller companies. And so we saw that those companies that who had partners had made bigger strides and maybe then you also spread the risk.”

#### *4.2.3 Support and selection committee factors*

Having a business skills support program is highly important to interviewees who have such a program. Organisations that don't have such a program gave the reason that it either wasn't within the scope of an SBIR-based procedure, in their opinion, or was due to capacity restrictions. These programs are primarily aimed at relatively new businesses where they "teach them to become successful businesses", and this is done by, for example, providing training in entrepreneurial skills, marketing or how a business can protect their intellectual property.

Another way interviewees aim to support their companies is less formal, but they try to provide guidance on how to deal with governmental organisations. For example, by ensuring that companies know how procurement processes work and have basic financial structures in place. The last support factor is the factor that was mentioned in every interview and in two evaluations, namely providing networking and showcasing opportunities for participating companies. The main reason why this is deemed important is because SBIR funding is often not enough to fund the innovation fully, and therefore, participating companies require additional promotion to attract new partners, customers, and/or investors. Furthermore, this is an opportunity for the government to show an audience what they are funding and what the results are. However, this should

not only be done at the end of the procedure. According to many interviewees this is an ongoing priority because it could also attract, for example, new partners which will strengthen the innovation. One evaluation even mentioned that "It creates conversations with potential partners and investors that would not otherwise happen. Often, these conversations lead in directions away from the SBIR technology. But that should be viewed as a success!" (National Academies of Science, 2016, p. 184).

A new factor category is the selection phase. In this case, it primarily focuses on the composition of the board or committee that chooses which companies can enter the SBIR-based procedure with their proposed innovation. There were apparent differences between the approaches in this area during the interviews. Although there were generally no statements on an expert category's effect on the chance of commercialisation, the choice was made to include these findings because there is a clear difference between the categories and they were consistently mentioned.

Four types of experts can be involved at the selection stage: commercial experts, policymakers, science experts, and technical experts. Commercial experts have experience with venture capital and are being involved to give an opinion on the commercial viability of the proposed innovation. One organisation only involved this expert in the selection phase between phase I and phase II. The reason for this is that for the first phase, they are only interested in the technical viability of an innovation due to their goal of getting innovations they can use themselves, and commercialisation is not relevant for them in the early phases. Another organisation did not involve commercial experts and let the commercialisation potential be judged by someone else. A majority of the interviewed organisations involve policymakers to ensure that the proposed innovation is in line with the long-term goals of the governmental organisation. A couple of organisations were clear that they do not involve policymakers, in their experience, the involvement of policymakers has a bad influence on a successful outcome because they believe that experts should look more broadly than just "pure policy-related aspects". Several organisations indicated that they involve science experts to assess the proposed innovation's scientific soundness. The other organisations did not indicate anything related to scientific experts.

Almost all organisations mentioned the involvement of technical experts, people who are not necessarily scientific but know a lot about the subject area, and are, for example, people who will actually need to work with the proposed innovation if it succeeds.

The findings for the selection phase are summarised in table 6 below, with some additional context.

Expert category	How often found (n=6)	Additional context
Commercial experts	4 from the start, 1 from phase II	When and how commercial experts are used could be based on the previously mentioned goal of the SBIR-based procedure. When the eventual goal is to make a product that should (also) solve a societal problem it seems logical for organisations to use this expert from the start. When the goal is to solve a problem within the organisation, the main issue is technological viability and not commercial viability because the organisation can assess for itself if the proposed innovation can solve its problem. However, there is also an organisation among the interviewees that has the latter goal but still uses commercial experts from the start, because they argue that they themselves can never be the sole customer of a company, and therefore commercial viability is a condition for a successful innovation that will solve their organisational problem.

Policymakers	4	Four organisations use policymakers to ensure that the proposed innovation is in line with the goals set by the organisation. According to them this also helps create clarity for the organisation and the company because the innovation is clearly part of a broader strategy or development. Two organisations were clear that they prevent to work with policymakers if possible because according to them these policymakers often tend to only focus on policy impossibilities instead of innovative possibilities.
Science experts	3	Half of the organisations mentioned scientific experts being involved and the other half did not mention anything about this category. In terms of context it is notable that two of the organisations who didn't mention scientific experts have a scientific nature. These organisations did mention however that they always use technical experts from their own organisation and these technical experts may be able to cover the scientific soundness of the proposed innovation with their academic technical background.
Technical experts	5	Technical experts are almost always used, and this can be in various degrees, from people who will use the innovation daily to people with a strong technical background within that industry. The one organisation who didn't mention this expert category could have forgotten to mention this, there are no indications for this organisation that they have a strong reason to not include this expert.

Table 6. A summary of the selection committee findings with additional context

#### 4.2.4 DMoD specific

When asking questions about bridging phase II and phase III, interviewees often talked about the 'valley of death', which in their own words means the gap between these two phases. The ways in which they attempted to bridge this gap varied and often depended on applicable laws within that country. An example of how organisations try to bridge this gap is by having an additional program or phase after phase II where they provide additional funding as long as it is evenly matched by an outside investor to ensure that there is commercial interest in this innovation and to reduce the inherent risks of such an investment. However, it depends on the applicable laws in any country if such a structure is allowed.

Regarding the defence industry specifically, interviewees indicated that it is probably important to focus on dual-use innovations, which is an innovation that could be applied in the defence industry and other industries, to increase the commercial viability of innovations and reduce the corresponding risks. In line with previous findings around the focus on the external market, one interviewee indicated that the DMoD should analyse what the major defence companies are currently funding. This is because in multiple cases these companies should be the ones to invest in some of the innovations that enter the DMoD SBIR-based program because the funding from the SBIR-based program is not enough. By analysing this the DMoD can better assess the commercial viability of applicants. The importance for this analysis is further supported by an interviewee who highlighted the importance of external investors in the defence industry. This interviewee stated "that means that they need to incentivize private capital to go into companies that work on security, defence challenges.". The reason for this statement is that a lot of investors are reluctant to invest in the defence industry, and according to this interviewee, it is therefore important to analyse and incentivize investors' behaviour. An overview of all the identified factors is given below in table 7

<i>Factor category</i>	<i>Factor description</i>	<i>New or existing factor</i>
Finance	Funding based on market characteristics is hinted as being positively related with commercialisation rate	New
	Funding based on R&D budget is hinted as being negatively related with commercialisation rate	New
	External investors are important for additional financing of the innovation	Existing
Strategic R&D	Provide access to government facilities and resources because this support collaboration and alignment with practice. This increases the commercialisation rate.	New
	Be accessible and not too formal because this increases clarity. This increases the commercialisation rate.	New
	Creating more clarity before the application increases clarity on the goals of the SBIR-based innovation project. This increases the commercialisation rate.	New
	Providing a permanent contact person helps in promoting clarity and accessibility. This is experienced as a positive contribution to the commercialisation rate.	New
	Experienced project manager at the company are important to make sure that the project is properly managed and all interests from stakeholders are taken into account. Taking this into account when selecting and coaching companies is considered as a positive contribution to the commercialisation rate.	Existing
	Partnerships between companies are helpful in creating better innovations, because more expertise is being involved.	New
	A lack of knowledge about the external market is experienced as a hindering factor for SBIR-based programs. Not having a clear idea on what the outside world is looking for hinders in selecting and steering towards impactful innovations.	New
	Measuring the impact of the SBIR-based program is considered as an improvement area. Knowing what parts of the SBIR-based program is helpful, which aren't and how companies are progressing after the SBIR-based program can help in increasing the commercialisation rate.	New
	Having procurement involved at an early stage is indicated to be helpful to make the commercialisation easier, because the things that procurement is looking at to buy the innovation were known and involved from the beginning.	New
Support	Business skills support programs are helpful in increasing the commercialisation rate because it promotes various business skills at the company such as entrepreneurship, copyright law and project management.	Existing
	Support in doing business with the government is indicated as a factor that helps in creating clarity for the company. New companies may have no experience with the formal nature of governments and its procedures. Support with this new experience could have a positive result on the commercialisation rate.	New

	Providing networking & showcasing opportunities is positively related with the commercialisation rate. The reason for this is that these opportunities provide access to new customers, investors or partners. These are all positively related with the commercialisation rate.	Existing
Selection phase (See table 6 for explanations)	Commercial experts involved	New
	Commercial experts involved from phase II	New
	Policy makers involved	New
	Science experts involved	New
	Technical experts involved	New

Table 7. An overview of the results from the interviews and secondary data sources. In the right column it is indicated if the factor is also found in past research.

#### 4.3 cross-case results

An interesting recent development is that the more experienced organisations conducting SBIR-based procedures are shifting their focus from internal procedures to the external environment. Multiple experienced organisations said that in the past 10-15 years, they have put a lot of focus and improvement efforts into support programs and ways to support companies within the SBIR-based procedure. Recently, these mature organisations shifted their focus external, for example, towards monitoring where venture capital is going or focussing on the start of the procedure, and then primarily on ways to "widen the funnel" of potential participants by creating more clarity before the application phase. Behind this movement seems to be the realisation that it isn't possible to adjust the external environment to the desired innovation, instead organisations try to understand the outside world and what they desire from new innovations

Another clear trend is that SBIR-based programs need to monitor and measure more within their program and possibly the external environment. One common conclusion from the secondary data sources is that currently there is no good data on the long-term impact of SBIR-based procedures. This meant for these evaluations that there is no good data on best practices and the long-term effectiveness of the procedure. During the procedure there is often data on the companies and their performance within program, but what happens after a company leaves the program is often unclear. Therefore, it is unclear how much of a company's success can be attributed to their participation in an SBIR-based procedure.

## 5. Discussion and conclusions

### 5.1 Discussion of results

The findings of this thesis provide several interesting insights in how SBIR-based procedures are developing and what is experienced as being an influencing factor in procedure. There are major differences between the factor overview from the literature review and the one from the interviews and secondary data sources in this thesis. When looking at the finance factors from the literature review it can be seen that a lot of these factors are quantitative in nature, and many interviewees did not have enough confidence to make substantial statements about the impact of funding amounts. They mentioned that funding is essential, but the additional benefits such as support, showcasing and networking are also important. Therefore the only conclusion on funding that can be made here is that there are differences on how organisations decide on the amount of funding. However, the finding that there are two ways how organisations can decide on the amount of funding, having fixed amounts or adjusting funding based on the market characteristics of the innovation, is a new finding. There is no clear evidence on which one is more effective, however there are indications that basing the amount of funding on market characteristics is more effective. This is because the NIH evaluation recommends switching from fixed amounts to a more flexible and market characteristic based system.



Surprising results have been found in the strategic R&D category, due to the qualitative nature of this study interviewees went in-depth about the informal aspects of SBIR-based procedures and assessments and evaluations supplemented these. A lot of emphasis was placed on the need for these procedures to be accessible, clear and as informal as possible. A factor that is closely related to the previous finding on accessibility, clarity and informality is having a permanent contact person for participating companies, because this is a more practical reflection of the need for accessibility, clarity and informality. Another factor closely related to the same previous factor is providing access to government facilities and resources. An excellent example would be allowing a company in the program to use certain testing facilities with operational staff present to give real-time feedback. Having permanent contact persons, providing access to facilities and not writing long technical calls as mentioned in table 5 are all examples of ways to accomplish this focus area, which many interviewees have signaled. Looking at the context it seems that being accessible, clear and informal is important in all situations. The core of this importance is that it is important to make sure that the interests of the organisations and company are always aligned, and in order to ensure this interviewees indicated that accessible communication is important because it guarantees that any questions will get answered, clarity ensures that the goal of both parties is always clear and aligned and informality in writing and contact makes approachability and understandability easier.

A recent development is that experienced organisations are shifting their focus from internal factors to the outside environment, sometimes called the external market in this thesis. The SBIR-based program can utilise the information about this external market by adjusting the innovations the program looks for and to have a clearer picture on how to steer towards commercialisation if an external investor is necessary. Even if an external investor is not necessary it is still important to look at the outside world because, for example, where venture capital money is going also says something about the commercial interest in the kind of innovations, and this therefore also an indicator for commercial interest in a certain innovation. The logic behind 'widening the funnel' is that more applications increase the competition and the chance of a promising company and innovation among the applicants. Examples that were given on how to do this is are, for example, video introductions for every call and more broad promotions. It is also interesting to note that video introductions also has a connection to the need for clear and informal communication, but here in a promotional context.

A prominent development within the last decade has been the development of better business support programs for organisations who have such a program. Every organisation with such a support program said that this has been an important factor in improving their SBIR-based procedure. Furthermore, providing networking and showcasing opportunities is seen as one of the major benefits for companies participating in these procedures, as this can help a company progress in innovation. These two factors were the most mentioned and discussed during the interviews. Interviewees stressed that they are fundamental in stimulating innovation, especially for smaller businesses. It could be argued that larger companies don't need support for entrepreneurial skills, but even for those larger businesses it is considered useful to have opportunities to network and showcase their innovation to potential investors or partners.

The selection phase was discussed in every interview, not in the evaluations and assessments. Only some indicative conclusions can be drawn on the effectiveness of any of those experts in the selection phase because this thesis merely relied on qualitative data and the interviewees did not go over each expert and indicate if and why they do or do not use each expert. Also, this topic has not been discussed in the evaluations. However, it is clear that there are differences and therefore this is still included because it could still be relevant to future researchers or organisations looking to set up an SBIR-based procedure. The results provide an indication that commercial experts could be less relevant in situations where the organisation's goal is to solve a problem they have. The reason for this is that the organisation considers themselves as the potential customer and if they

think that the innovation will work the only question that remains is if the innovation is technically possible. However, the results also indicates that there could be reasons why this isn't true because a governmental organisation can almost never be the sole customer of a company. The results in combination with the context also indicated that science experts should be used in situations where the technical experts within the selection committee or the organisation don't have a scientific background. When this is the case the purpose of dedicated scientific experts seems to reduced.

The differences between the factor overview from the literature review and the one from this analysis are partially caused by the qualitative nature of this research, and therefore interviewees were not confident enough to make strong statements on topics such as finance and the impact of the funding amounts. It could be argued that the lacking performance monitoring and data collection is one of the reasons why professionals don't have strong opinions about funding amounts. Another reason is the nature of the interview guide, which was created with an exploratory nature in mind. The goal was to find new factors, therefore interviewees were not asked to confirm or disprove previously found factors. As a result interviewees mainly talked about what they experienced throughout the years as experts, and what they still want to improve on. This created factors such as clarity and ways to improve that, which is something that cannot always be implemented into a procedure. It is more of a way of thinking in some instances, such as the factor of not being too formal in your communication. This also means that the previously found factors within the literature are still valid and relevant to take into account, and the newly found factors within this thesis should be seen as an addition to them.

Since this thesis aims to create an overview of factors that influence SBIR-based procedures table 8 was created. In this table are the factors from the literature review, the interviews and the secondary data sources. Factors found within previous research and in either the interviews or the secondary data sources were combined. Each factor has a description and information on the context in which it is found.

<i>Factor category</i>	<i>Factor</i>	<i>Source and additional context</i>
Finance	More phase I instead of phase II financing is positive for attracting VC and successful exits	Only found in previous research (Howell, 2017; Toole & Turvey, 2009)
	Higher total SBIR award size is positive for avoiding project failure	Only found in previous research (Link & Wright, 2015)
	No correlation between more SBIR funding and commercialisation	Only found in previous research (Link & Ruhm, 2009)
	Funding from other sources than the SBIR program is positive for commercialisation rate	Found within previous research (Link & Ruhm, 2009; Lerner, 1999; Bottazzi & Da Rin, 2002) and within during interviews. This increases the funding and confirms commercial viability of the innovation.
	Increasing phase II funding is positive for steering innovation	Only found in previous research (Selviaridis, 2020)
	Funding based on market characteristics is hinted as being positively related with commercialisation rate	Found within interviews and an evaluation. The recommendation in this evaluation is why this hint is present. During the interviews only information was given on what the funding is based on.
	Funding based on R&D budget is hinted as being negatively related with commercialisation rate	Found within interviews and an evaluation. The recommendation in this evaluation is why this hint is present. During the interviews only information

		was given on what the funding is based on.
Strategic R&D	Prior firm R&D experience is positive for avoiding project failure	Only found in previous research (Link & Wright, 2015; Panne et al., 2011)
	Larger firm size is positive for avoiding project failure	Only found in previous research (Link & Wright, 2015)
	Involvement from universities is positive for increasing commercialisation rates	Found within previous research (Link & Ruhm, 2009; Siegel & Wessner, 2012; Audretsch et al., 2019; Toole & Czarnitzki, 2007) and interviews indicated that they use scientific experts during the selection phase.
	Multi-disciplinary character of the R&D is positive for the technological and commercial viability of an innovation	Only found in previous research (Panne et al., 2011)
	Early input from SBIR participants into the creation of a tender to successfully source new innovations	Only found in previous research (Vroljik et al., 2021; Pihlajamaa & Merisalo, 2021)
	More coordination and cooperation within the government to influence the market and their innovation incentives	Only found in previous research (Selviaridis, 2020; Iossa et al., 2018)
	Make projects fit into a broader national innovation program to make sure that the innovation is relevant	Only found in previous research (Selviaridis, 2020), although one interviewee did briefly hint towards this factor. It was not included as an interview factor because it was in a slightly different context and only briefly mentioned.
	Public servants need to have the right skills and incentives to foster an innovative mindset. This is required to aid in developing innovative solutions.	Only found in previous research (Iossa et al., 2018)
	Provide access to government facilities and resources because this supports collaboration and alignment with practice. This increases the commercialisation rate.	Only found in interviews. This factor was found in contexts where there is a practical connection between the innovation and the government organisation. One example could be using a government lab to test certain functions.
	Be accessible and not too formal because this increases clarity. This increases the commercialisation rate.	Found in the interviews and multiple evaluations. Companies participating in an SBIR-based procedure benefit from accessibility and less formal procedures and ways of communicating. This is also the foundation for multiple other factors.
Creating more clarity before the application increases clarity on the goals of the SBIR-based innovation project. This increases the commercialisation rate.	Found during the interviews and in secondary data sources. This was mentioned by a small amount of interviewees, but they did mention this as an important factor and is mentioned by a secondary data source. Therefore it is included.	
Providing a permanent contact person helps in promoting clarity and accessibility. This is experienced as a positive contribution to the commercialisation rate.	Found during the interviews and in secondary data sources.	

	Experienced project manager at the company are important to make sure that the project is properly managed and all interests from stakeholders are taken into account. Taking this into account when selecting and coaching companies is considered as a positive contribution to the commercialisation rate.	Found in previous research (Müller & Turner, 2007) and during the interviews.
	Partnerships between companies are helpful in creating better innovations, because more expertise is being involved.	Only found during the interviews.
	A lack of knowledge about the external market is experienced as a hindering factor for SBIR-based programs. Not having a clear idea on what the outside world is looking for hinders in selecting and steering towards impactful innovations.	Only found during the interviews. This factor is only clearly mentioned in one interview, and hinted towards in another. However, these two interviewees were from the two most experienced and largest SBIR-based organisation among the interviewees. Therefore this factor was included because it signals a new development.
	Measuring the impact of the SBIR-based program is considered as an improvement area. Knowing what parts of the SBIR-based program is helpful, which aren't and how companies are progressing after the SBIR-based program can help in increasing the commercialisation rate.	Found during the interviews and in all of the secondary data sources.
	Having procurement involved at an early stage is indicated to be helpful because it makes the commercialisation easier, because the things that procurement is looking for to buy the innovation were known from the beginning.	Found during the interviews.
Support	Open information sharing between firms, government and end-users is beneficial to address systemic failures in innovation	Only found in previous research (Vroljik et al., 2021; Selviaridis, 2020)
	Business skills support programs are helpful in increasing the commercialisation rate because it promotes various business skills at the company such as entrepreneurship, copyright law and project management.	Found in previous research (Cooper, 2003), during the interviews and in the secondary data sources.
	Support in doing business with the government is indicated as a factor that helps in creating clarity for the company. New companies may have no experience with the formal nature of governments and its procedures. Support with this new experience could have a positive result on the commercialisation rate.	Only found in the interviews. This was found in two interviews with SBIR-based organisation who exclusively deal with small businesses. It is unsure if this is also relevant for SBIR-based organisations who also allow larger companies. These larger companies probably have more experience in doing business with the government.
	Providing networking & showcasing opportunities is positively related with the commercialisation rate. The reason for this is that these opportunities provide access to new customers, investors or partners. These are all positively related with the commercialisation rate.	Found in previous research (Vroljik et al., 2021), during all of the interviews and in secondary data sources.
Selection phase (See	Commercial experts involved	Only found in the interviews
	Commercial experts involved from phase II	Only found in the interviews

table 6 for explanations)	Policy makers involved	Only found in the interviews
	Science experts involved	Only found in the interviews
	Technical experts involved	Only found in the interviews

Table 8. A combined overview from previous literature, interviews and secondary data sources about factors that have an influence on SBIR-based procedures

### 5.2 Implications for the literature

This thesis brings three clear implications for the existing literature. Besides funding and the importance of non-SBIR funding (Link & Ruhm, 2009; Lerner, 1999; Bottazzi & Da Rin, 2002) there hasn't been focus on developments outside of the SBIR-based procedure in previous research. This thesis clearly identified that recently this has been a new focus point for the more experienced and or mature SBIR-based procedure organisers. Therefore, the first contribution to the literature is a new development in the area of SBIR-based procedures, which focuses on the influence of the external environment and how this can be used to increase the impact of the SBIR-based program.

Secondly, accessibility and less formal procedures is a factor that is clearly underlined by the data in this thesis, and which is also reflected in multiple other factors such as permanent contact persons. This has not been clearly found to be a relevant factor within the literature review. The only thing previously found is that open information sharing between the government and participant is important (Vrolijk et al., 2021; Selviaridis, 2020), and this is related to factors such as having a permanent contact person. However, this doesn't cover the complete context of accessibility and less formal procedures. Therefore this thesis helps in creating a clearer picture on the less measurable factors in SBIR-based procedures such as accessibility as opposed to, for example, quantitative data such as the correlation between funding amounts for the specific phases and a commercially available product.

Thirdly, in order to deal with research limitations (Wessner, 2007) and to provide richer and better insights into the workings of SBIR-based procedures this thesis identified two goals that an organisation may have when performing an SBIR-based procedure, namely pursuing innovations for societal gain or to solve a problem within their own organisation. This difference having an effect is seen in this thesis when looking at the composition of the selection committee, and it is likely that this has impact on more factors. The potential impact of this factor is that it could change the entire design philosophy of a new SBIR-based procedure. This could mean that organisations should shift away from creating more general 'one-size-fits-all' procedures. When this is further researched, organisations should start with their goal and then know which factors are relevant for that specific procedure.

One additional small contribution to the literature is the introduction of the term SBIR-based procedures. Outside of the United States multiple procedures follow mostly the same structure while carrying another name due to those procedures not only being focused on small companies (Tredgett & Coad, 2013), which is inherently in the name 'Small Business Innovation Research' and therefore not applicable to those programs. Hopefully, this thesis will contribute to this awareness and encourage researchers to have a broader scope regarding 'SBIR research'.

### 5.3 Implications for policy and practice

The biggest contribution to practice of this thesis is that it brings additional insights into factors that influence the success of an SBIR-based procedure which can be used to improve existing procedures or as a help when trying to create a new SBIR-based procedure. This thesis collected previously, still valid, factors and supplemented them with new factors that haven't been found before in SBIR-related research. A clear recent development is the growing focus on external developments such as the direction of private capital investments and developments in the market of the innovation. Where capacity allows, this can be used by multiple

organisations as a new direction for improvement. Furthermore, it is a reminder for all organisations conducting an SBIR-based procedure to ensure that it is accessible and not too bureaucratic and that expectations and interests are always aligned. Creating this with for example a dedicated contact person is one way to do this, among other things. For the DMOd the findings indicate that they should focus on dual-use technologies and due to the nature of the defence industry they in particular should focus on analysing the behaviour of the big defence companies within the industry. They could also try to be creative within their legislative room and look at, for example, an additional phase between phase II and III with euro to euro matching from an external investor as indicated by one interviewee.

#### *5.4 Limitations and future research*

It is important to note that the purpose of this study was not to confirm or even disprove previous research exclusively. Therefore, there were no targeted questions to confirm or disprove every previously found factor. This means that although some factors may have not been found in this thesis, this does not mean they are invalid. Furthermore, as Wessner (2007) noted that "Comparisons between SBIR programs at different agencies appear superficially more useful, but must be regarded with considerable caution..... the widely differing agency missions have shaped the agency SBIR programs, focusing them on different objectives and on different mechanisms and approaches. Agencies whose mission is to develop technologies for internal agency use via procurement—notably the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA)—have a quite different orientation from agencies that do not procure technology and are instead focused on developing technologies for use outside the agency." (p. 109). An example of this being true is the difference in whether to include commercial experts or not, and this caution should be kept in mind when reading this thesis. There is currently no research on the actual differences between SBIR-based programs with different goals, there are only warnings. For future research it would be useful to know about these differences and how to take them into account.

The previous point highlighted that not every single factor is relevant in every scenario, and the international context of this study furthermore strengthens this, because internationally SBIR-based procedures are not only used for SME's (Tredgett & Coad, 2013) and some factors identified within this thesis could be argued as being more relevant for smaller companies than larger companies. A support program focussing on managing a company could be considered less relevant for larger companies. However, it also cannot be concluded that there is no possibility for a helpful support program aimed at larger companies.

Future research could be focused on testing these newly found factors more rigorously in a dedicated study. The newly found factors are, as a matter of fact, experts' experiences and opinions, and therefore could be false when tested quantitatively. Furthermore, there is a new potential research area with the discovery that organisations are currently in the process of transitioning their view towards the external environment, and this could be a promising research area as it could lead to interesting findings about the influence of external factors on the performance of the internal procedure. Lastly, there is unclarity about the composition of the selection board, and there are signals that the optimal composition of the board could be different based on the organisation's objective. This and the different objectives themselves could be an interesting future research avenue.

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#### Appendix A. *An overview of the used literature*

Research	Domain	Category	Phase(s)	Data source	What is 'success'	Identified relevant factor
(Howell, 2017)	SBIR	Finance	1,2	Data from the U.S. Department of Energy's Small Business Innovation Research program from 1983 to 2013.	Receiving VC, patents, revenue, survival, successful exits	Phase 1 grants have a much bigger impact than phase 2 grants, relocating money from late to early phases could enhance effectiveness
(Link & Wright, 2015)	SBIR	Finance, Strategic R&D	1,2	Data from 1878 Phase II R&D projects funded through the U.S. SBIR program	Avoiding project failure	Prior R&D experience is positive, SBIR award amount is positive, female principal investigators reduce failure probability, larger firm size increases it
(Toole & Turvey, 2009)	SBIR	Finance	2	Data from the US Small Business Administration (SBA). This covers the 1983–1999 period for 11	Attracting follow-on venture capital	Phase 1 SBIR funding can increase commercialisation chances due to more follow-on capital

				participating agencies.		
(Link & Ruhm, 2009)	SBIR	Finance, Strategic R&D	1,2	Data from the National Research Council, covering NIH Phase II SBIR projects from 1992 to 2001.	Measured by commercialisation of the project	No correlation between more SBIR funding and commercialisation, university involvement positive, non-SBIR funding positive
(Lerner, 1999)	SBIR	Finance	1,2,3	Data from a unique database compiled by the U.S. General Accounting Office, analysing SBIR awardees and matched firms over a decade.	Growth and attracting venture financing	SBIR awardees grow faster and are more likely to attract venture financing when in regions with substantial venture capital activity, attracting SBIR funding has a signalling function towards Venture Capitals
(Bottazzi & Da Rin, 2002)	Venture Capital	Finance	1,2,3	Data is hand-collected from listing prospectuses and annual reports of companies listed on Euro.nm from its inception to December 2000.	Effectively nurturing fast-growing companies and supporting the creation of innovative companies	VC funding is deemed as the best way to finance new high-tech companies, with considerable hard and soft support from the funder
(Toole & Czarnitzki, 2005)	SBIR	Finance, Strategic R&D	1,2,3	Data from NIH's CRISP database and other sources, focusing on SBIR firms associated with biomedical	Achieving follow-on venture capital, program completion and patenting activity	SBIR doesn't compete with VC, academic involvement is positive for VC funding, SBIR program completion and patenting activity

				academic scientists.		
(Siegel & Wessner, 2012)	SBIR	Strategic R&D	1,2	Data from the US SBIR program, DoD database	Commercialisation outcomes such as sales, new employees and patents	Ties to universities is positively correlated
(Audretsch et al., 2019)	SBIR	Strategic R&D	1,2	Data from a random sample survey of projects funded by the SBIR program, conducted by the National Research Council (NRC)	Number of scientific papers submitted for publication resulting from SBIR projects	Involvement of a university in the funded project leads to more scientific papers
(Cooper, 2003)	SBIR	Support	2	Reviews of different SBIR programs and different published studies	The program's ability to move federal research ideas into private markets, sales, employees and external investments	A support program is necessary to aid with market knowledge and marketing skills, insufficient funding is primary reason for discontinuation SBIR project after phase 2
(Panne et al., 2011)	Innovation	Strategic R&D	1	Literature comparison of factors across multiple studies focusing on innovation success and failure	Technological and commercial viability of the innovation	Several positive factors for innovation; the culture within the firm, the experience they have with innovation, the multi-disciplinary character of the R&D team, the explicit recognition of the collective character of the

						innovation process
(Müller & Turner, 2007)	Project management	Strategic R&D	1	Worldwide web-based survey with 959 responses, assessing importance attached to project success criteria and project success rates	Meeting various criteria including end-user satisfaction, supplier satisfaction, team satisfaction, stakeholder satisfaction, time, cost and quality	Certification of project managers is important for innovations
(Vrolijk et al., 2021)	Innovation contest	Strategic R&D, support	1,2	In-depth case study of NASA's 3D Printed Habitat Challenge (3DPH Challenge), including interviews with 49 individuals involved with 3DPH	Success is defined as achieving a range of benefits beyond just the solutions to problems, including network- and technology-related benefits that appear throughout the contest process	Network possibilities, early input from participants and open information sharing is positively correlated
(Pihlajamaa & Merisalo, 2021)	Procurement of innovation	Strategic R&D, support	1,2	Case study of two hackathons, data sources include documents, interviews, reports, presentation and interviews	Sourcing novel technologies and engaging in conversations with companies	Learning from internal stakeholders and early involvement of potential participants is beneficial
(Selviaridis, 2020)	Pre-commercial procurement	Strategic R&D, support, finance	1,2	study of the UK Small Business Research Initiative	Influencing the activities, capabilities, and behaviours of actors in the	Fit it into broad national program, increase phase 2 funding, increase interactions

				(SBRI) program, the research involved 33 interviews across 30 organisations	innovation process, particularly in addressing systemic failures in innovation.	between parties, more coordination within the government departments and a more innovative mindset within the government
(Iossa et al., 2018)	Pre-commercial procurement	Strategic R&D	1	Analysis of literature, case studies and legislations	Effectively addressing market failures in innovation through public procurement, influencing firms' innovation incentives, and boosting competitiveness and growth.	Skills, incentives and cooperation from public servants is necessary for a good tender, multi-disciplinary teams are necessary for strategic design and more innovation-oriented thinking is necessary