TKI WIND OP ZEE
Topsector Energie

Valorisation perspectives for offshore wind energy innovation projects

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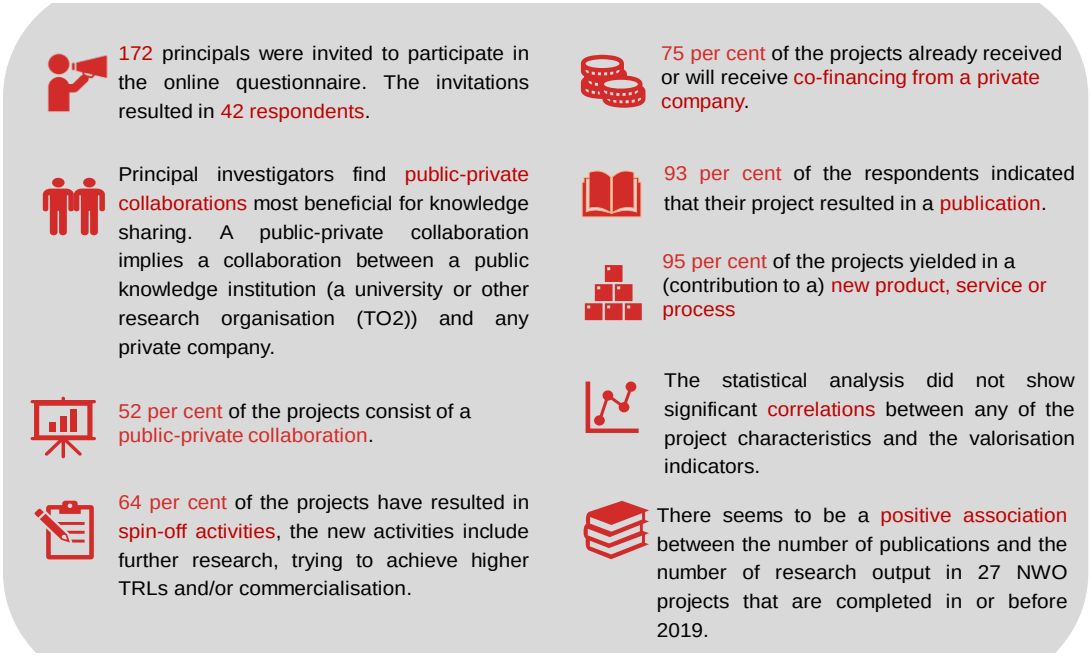
Summary

TKI Wind op Zee connects and supports researchers and organisations to enhance their impact on a renewable offshore energy system. This study reviews the success of knowledge valorisation for about 200 projects in this specific field. Although knowledge valorisation seems to be rather successful, the lack of complete data

Aim of this study
Knowledge valorisation refers to the process of making scientific/academic research available for practical use. Funding for research on renewable offshore wind energy is available via large-scale grants and subsidy programmes from the Ministry of Economic Affairs and Climate Policy (Economische Zaken en Klimaat, EZK) and the Ministry of Education, Culture and Science (Onderwijs, Cultuur en Wetenschap, OCW). TKI Wind op Zee connects and supports researchers and organisations doing research in this field.

This current explorative study aims to measure the level and quality of knowledge valorisation of successfully completed research projects in this field. To do so, available (final) project reports are analysed, meta-data on the projects has been collected (e.g. number of publications and product contributions), and a survey amongst the principal investigators has been executed. Figure S.1 gives an overview of the outcome of the survey. The results of this field work are combined with a literature study on the relevant indicators of knowledge valorisation.

Figure S.1 Survey amongst principal investigators suggests knowledge valorisation is successful



Source: SEO Amsterdam Economics (2021)

The study provides insights into the success of knowledge valorisation in the examined research projects. Overall, knowledge valorisation seems to be successful and

incorporated from the start of the research projects. This study, however, also provides some guidance on how to monitor and evaluate knowledge valorisation in future projects. Conclusions about monitoring include: basic information about finished projects is not (readily) available, research projects (groups/initiatives) are not monitored after finishing the project losing valuable insights into long term valorisation and a benchmark is not available.

Successful knowledge valorisation
The outcomes of the online questionnaire suggest a high level of valorisation in the examined projects. The majority of the principal investigators indicates to have a valorisation plan before the start of the project. Even more striking is that 95 per cent of the principal investigators indicate that their research funded by the Ministry of Economic Affairs and Climate Policy (EZK) resulted in a new product, service or process that can be utilised for future research/projects.

Main drivers for successful innovation and knowledge valorisation
Knowledge exchange, careful documentation, knowledge utilisation, coordination and collaboration are the most important prerequisites of successful knowledge valorisation. Knowledge valorisation plays an important role throughout the entire innovation process. Exploratory research and knowledge sharing activities are most important in earlier stages of innovation. In later stages, commercialisation and public-private collaborations are the most important drivers of knowledge valorisation.

Main impediments preventing successful knowledge valorisation
The online survey yields two main reasons for not achieving any knowledge valorisation. The first one mentioned is that during or after the research project, the product, process, or service is not economically viable. The second reason mentioned is that the product, process, or service was not ready to enter the market. It is often mentioned that further research is required. This underlines the importance of being able to monitor knowledge valorisation over time, in particular after the research project finished.

Differences between type of subsidy and knowledge valorisation?
The resulting correlations between project characteristics and knowledge valorisation indicators are rather low, and the vast majority is also not statistically significant at a 5 per cent significance level. The most surprising result is the negative correlation between the duration of a project and the number of publications. Longer projects seem to have a lower number of publications.

Recommendations for more insights into knowledge valorisation

- This study underlines public-private collaboration's importance to achieve knowledge valorisation in innovative (applied) research at mid-range Technology Readiness Levels (TRLs). In the current funding instruments by both RVO and NWO, a public-private collaboration is not a prerequisite, whereas the results of this analysis show that this would increase the chance on a successful knowledge valorisation.

- Monitoring of the research projects near and right after completion should be improved upon.
- Monitor and follow research from a certain research group, consortium or network over a longer time (including over different research projects).
- Introduce a pre-specified format for delivering the final report of a research project.
- Set up a benchmark for the expected output both in quantitative and qualitative dimensions.

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1 Introduction

This study reviews completed research projects in offshore wind energy. The review focusses on the level and main drivers of knowledge valorisation. Knowledge valorisation is essential to enhance the societal use of the outcomes of these research projects (partially) funded by the Dutch government.

Background
TKI Wind op Zee – Top consortium for Knowledge and Innovation Offshore Wind Energy – is a public organisation with the mission to enhance research, development and innovation in the Netherlands, focusing on offshore wind in the Netherlands. The ultimate goal of this top consortium is to facilitate the transition to a sustainable, reliable and affordable energy system.

Large-scale grants and subsidy programmes in this field are facilitated by the Ministry of Economic Affairs and Climate Policy (EZK) and the Ministry of Education, Culture and Science (OCW). Both the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland, RVO) and the Dutch Research Council (Nederlandse Organisatie voor Wetenschappelijk Onderzoek, NWO) award, administer, and manage these large-scale grants and subsidies. TKI Wind op Zee connects and supports Dutch organisations to achieve the largest impact possible, focusing on cost reduction and optimisation of the renewable offshore energy system, the integration of the energy system, and the integration to the wider economic and eco-system.

From 2014 onwards, 208 projects received funding via RVO for research projects relevant to TKI Wind op Zee. The amount of total public funding for these projects is approximately €135 million. As of 2021, 108 out of these projects are completed, representing a total amount of about €40 million. In addition, there are about 100 projects funded via NWO that do fit in TKI Wind op Zee.

In order to facilitate achieving the ultimate goal of a sustainable energy system, TKI Wind op Zee considers knowledge dissemination and valorisation of crucial importance. RVO has commissioned SEO Amsterdam Economics to perform an explorative study to measure the degree and quality of knowledge valorisation of completed projects within the programme. Such a study supports the identification of opportunities and threats regarding knowledge valorisation in innovative research projects. The lessons learned can be applied to increase the chances of successful knowledge valorisation in ongoing and upcoming projects in specifically the TKI Wind op Zee programme and generally other large-scale grants and subsidy programmes.

Knowledge valorisation, dissemination and innovation are closely related to each other. Knowledge valorisation is about transferring academic/scientific knowledge to practical use. Examples include the development of products or policies based on academic insights and can be found in social and technical sciences. In order to transfer this knowledge to practical use, it is necessary that the knowledge itself first spreads throughout society, for example, via academic publications, presentations and

collaboration. This is the field of knowledge dissemination. Innovation refers to something ‘new’, for example, a new product or service or an improvement in current organisational processes. So, knowledge valorisation requires, by definition innovation, but not all innovation leads to practical use (valorisation).

Research question(s)
This explorative study aims to measure the level and quality of knowledge valorisation of the completed projects recently supported by various subsidy grants. In other words, to which extent and by whom are the academic insights from the more than 100 projects used to create applied innovations (products, processes, services, etc.). To structure our study, the following four sub-questions are formulated:

To what extent do completed research projects in the TKI Wind op Zee programme show success in innovation and applicable knowledge?
What are the main drivers for the degree of successful innovation and knowledge valorisation?
What are the main impediments preventing knowledge valorisation from being created?
Are there any differences between type of subsidy programmes and knowledge valorisation?

Methodology
The study combines desk research, fieldwork, interviews with RVO and NWO and descriptive analyses. The desk research is instrumental to discuss previous literature aiming to measure knowledge valorisation. The close relation to knowledge valorisation and innovation is helpful here. The policy interest in valorisation is relatively new, whereas measurement of innovation and R&D efforts has been more developed over a longer period.

The second part of the desk research focuses on the analysis of the successfully completed projects in scope. This desk research contains a text analysis of summary reports of these projects as received by RVO and NWO. In addition, we look at potential outcomes, such as academic publications (knowledge dissemination) and contributions to (marketable) products (knowledge valorisation).

The fieldwork consists of an online survey among the principal investigators of the completed research projects in the TKI Wind op Zee programme subsidised via RVO or NWO. The response rate of principal investigators of projects funded via NWO is, unfortunately, rather low. This prevents us from focussing on NWO projects in isolation. For the projects funded by RVO we are able to link the survey results to the text analysis of the summary reports and other meta-data of the projects, hence allowing us to perform a more in-depth analysis of the opportunities and threats for knowledge valorisation for these type of projects. To gain additional insights into the TKI Wind op Zee programme, the different funding mechanism and the views on knowledge valorisation, SEO conducted interviews with three representatives of NWO and one representative of RVO. The insights of these interviews were mainly used as input for the online survey and research on funding mechanisms.

Structure of the report

The remainder of this report is organised as follows. Chapter 2 stipulates the relation between knowledge valorisation and innovation and the role and timing of valorisation within the innovation process. Furthermore, this chapter discusses the indicators for knowledge valorisation available in the literature. Chapter 3 focusses on the TKI Wind op Zee initiative, the several funding mechanisms within this initiative and the selection of projects for the explorative analysis. This analysis is subsequently conducted in Chapter 4 and contains meta-data of these projects and the main insights of the descriptive analysis of the online survey and text analysis of the project summaries. The conclusion and discussion of the results are given in Chapter 5.

2 Knowledge valorisation and innovation

In order to capitalise the efforts and outcomes of fundamental research, knowledge valorisation should be an integral part of the research project. There are many slightly different indicators of (successful) knowledge valorisation. These indicators differ regarding the innovation stage of the research.

2.1 Knowledge valorisation

Definition
Knowledge valorisation refers to the process of making scientific/academic research available for practical use. Related concepts such as knowledge transfer, commercialisation of research, and academic capitalism are now widely used by universities, applied research institutes, policy makers, and research funding agencies (Hladchenko, 2016). Knowledge valorisation has been regarded as the 'third mission' of universities (Leydesdorff & Etzkowitz, 1996).

Andriessen (2005) defines knowledge valorisation as the transfer from one party to another for economic benefit. A more extended definition is given by Van Drooge et al. (2011). They define knowledge valorisation as the process of value creation from knowledge by making knowledge suitable and accessible for both economic and social utilisation and by converting this knowledge into competing products, services, processes and new research or other activities. Compared with the definition of Andriessen (2005), the latter definition adds information on how knowledge valorisation could be achieved, does not exclusively restrict it to economic benefit and defines more explicitly outputs of valorisation. This more extended definition offers the advantage of more tangible and therefore measurable actions and indicators.

Prerequisites of successful knowledge valorisation by Mooren & Hessels (2019)
Mooren & Hessels (2019) performed a best practice analysis on successful knowledge valorisation in the field of research on water quality. They identify four important prerequisites for knowledge valorisation:

1 Knowledge exchange
2 Knowledge documentation
3 Knowledge utilisation
4 Coordination

Knowledge exchange differs from valorisation because the latter refers to the actual utilisation of knowledge whereas the former only refers to publishing or otherwise sharing the scientific insights gained from research. Without sharing knowledge, however, the probability of successful valorisation would be limited. Only if the academic researchers themselves are responsible for developing the new products, services and adding the economic or societal value, innovation may arise prior to knowledge dissemination. There should be sufficient exchange of existing and new

research insights. This exchange should take place within the direct research community but also outside this community. The latter refers to knowledge diffusion and is also considered by Mooren & Hessels (2019) as an important enabler of knowledge valorisation.

It is important to carefully document knowledge. This documentation should be available for both future scientific research and applied research. The open science movement, striving for open data, open science and open algorithms, is probably the most prominent global initiative to enhance the accessibility of academic research to all levels of society. Dutch universities and other academic partners adopted open access and open data as the future reference for publishing research. The 2019 annual monitor on open access publications shows that about twenty per cent of all publications from Dutch universities is fully open access and in total about 60 per cent is at least partially open access.[1] These shares show a clear increase over the past few years, up from 42, 50 and 54 per cent for 2016, 2017, and 2018 respectively.

Of course, knowledge documentation increases the direct use of the knowledge, the so-called knowledge utilisation. Knowledge utilisation is an essential phase of valorisation and refers to the actual application of newly generated knowledge through productive interactions with stakeholders. Knowledge utilisation aims to create societal and economic value. It increases the likelihood of societal impact of research and is considered an important part of any organisation's valorisation strategy.[2]

The fourth mentioned prerequisite is coordination. Coordination refers to collecting dispersed pieces of knowledge. In order to fully benefit from using existing and new knowledge and potential knowledge spill overs, the task of coordination is crucial. Lack of coordination may be regarded as a market failure in the innovation process because sharing knowledge and knowledge spill overs are so-called positive external effects. The owner of the existing and new knowledge may create value to other parties without receiving the benefits, in other words, the owner may not have the right economic incentive to optimally coordinate all relevant academic insight. Coordination is a public good and requires public action to guarantee the social optimal level of coordination (and research efforts) in society.

Collaboration as prerequisite

Besides the prerequisites mentioned by Mooren & Hessels (2019), there are several studies underlining the importance of collaboration in achieving knowledge valorisation. Cummings & Teng (2003) study several hypotheses regarding successful R&D using a mail survey amongst R&D executives in the United States. One of their hypotheses relates directly to collaboration. Based on their survey results, they show that the success of knowledge transfer into applied use depends crucially on a shared similar knowledge base of the parties involved. Collaboration is an important way to achieve such a common knowledge base. A common knowledge base reflects the number of research communities in which all partners published during a period of time. Gagnon (2011) reviews the barriers and success factors for the knowledge translation process into sound application of the knowledge in society. She concludes that active

[1] See https://www.openaccess.nl/en/in-the-netherlands/monitor

[2] NWO underlines the importance of knowledge utilisation, see, for example, https://www.nwo.nl/en/knowledge-utilisation

collaboration and exchange between researchers and knowledge users throughout the whole research process is of key importance. She identifies knowledge brokers/intermediaries, creating networks and communities as promising initiatives to support collaboration and subsequently knowledge valorisation.

In the interviews with representatives of NWO for this study, collaboration is also mentioned as one of the key prerequisites. According to the representatives, collaboration in the form of a partnership between a public research organisation and a private company are essential to successful commercialisation of research. According to their experience, they conjecture that public private partnerships are more successful when knowledge valorisation is targeted at social utilisation instead of economic benefits only. In the latter case, commercial stakes may prevent open collaboration from taking place.

2.2 Valorisation in the innovation process

The prerequisites of successful knowledge valorisation are closely related to the role of valorisation in the total value chain of research and innovation. Although the different studies into innovation knowledge valorisation come up with clear ordered schemes and processes, it is important to emphasise that they see the process of innovation and valorisation as interactive in nature and requiring feedback mechanisms throughout all stages of the research process.

Innovation process
The innovation process is defined as the path of translating new or existing knowledge into marketable solutions. The process covers all the phases from exploratory research to commercialisation. Holi et al. (2008) describes knowledge transfer from academic research into the commercial sphere as an important part of the innovation eco-system which has large economic and societal impacts. The innovation process as shown in Figure 2.1 is divided into six key activities, with knowledge transfer activities being in the middle of the process.

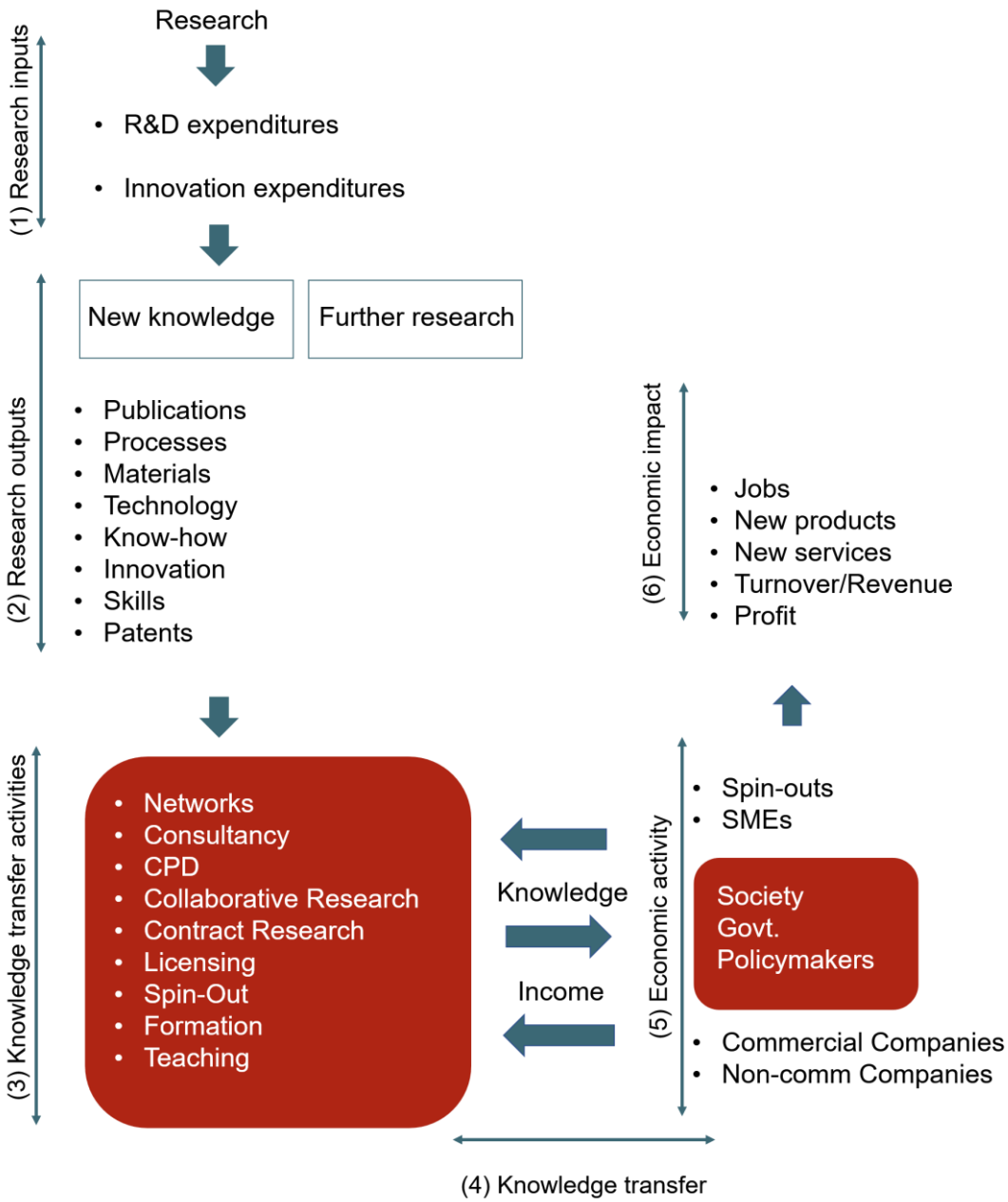
The first activity is research inputs. This activity refers to the R&D and innovation expenditures necessary for the generation of new knowledge. The expenditures refer to all costs for personnel and resources necessary for the knowledge generation process.

The second activity is research output. These outputs are the result of the R&D and innovation expenditures. New products/services are already output factors of the highest TRL and ready for commercialisation. New knowledge and input for further research serve as a start for new projects. Publications, know-how, skills and technologies serve as a start to knowledge sharing. These factors aid in spreading knowledge, starting collaborations and taking a project to the next TRL. Finally, patents serve as a measure to protect new knowledge and R&D efforts from infringement. A patent offers an investor a temporary monopoly and the opportunity to recover his investments.

The third activity is knowledge transfer activities. These activities serve as means to communicate research outputs to society and businesses. These activities improve the likelihood of new knowledge finding a potential end-user. These activities are common indicators used by Dutch universities to measure the level of valorisation.

The fourth activity is the actual process of knowledge transfer. This process is often associated with an income flow as knowledge is hardly available for free because of the high R&D and innovation expenditures in the research inputs phase.

Figure 2.1 The innovation process is divided into six key activities



Source: SEO Amsterdam Economics (2021) based on Holi et al. (2008)

The final two activities refer to the last phases of the research and are common indicators of successful innovation projects. The number of start-ups and both non-commercial and commercial companies involved in a project are a good indicator of how close an innovation is to utilisation. Policymakers are key in this activity because they have all sorts of regulations available to support matchmaking between carriers of knowledge and knowledge users. The number of jobs created, the additional economic value of these jobs (e.g. becoming more productive) and the revenue/profits generated are final measures of the success of an innovation process.

Technology Readiness Levels (TRLs)

Technology Readiness Levels (TRLs) are a widely used measurement system that supports assessments of the maturity of a particular technology or innovation in a coherent manner across different fields of technology. The system has been introduced and applied by NASA in the 1970s. The brief NASA white paper by Mankins (1995) defines, explains and summarises the nine technology levels. Many public (research) agencies, for example RVO and the European Commission, apply the definition of Mankins for the measurement of technology readiness.

Table 2.1 depicts the nine technology readiness levels as defined by Mankins (1995) and links each of these levels to the innovation indicators mentioned in the previous section. The TRLs are instrumental to the current phase of the innovation process and which strategy best fits to progress to achieving knowledge valorisation. It is clearly visible in the table that knowledge valorisation can only explicitly be linked to the last technology readiness level, level 9, via commercialisation. Hence, successful knowledge valorisation requires many preceding actions in the innovation process, implying that there are many moments within this process reasons may arise preventing successful knowledge valorisation.

Please note the similarities between the approach of Mankins (1995) and the description of the innovation process by Holi et al. (2008). The stage of research inputs as defined by Holi et al. (2008) corresponds mainly to TRLs one and two. The research outputs correspond to TRL three. The knowledge transfer activities and economic activity correspond to the levels four, five and six. These levels refer to development of the knowledge. Furthermore, economic activity includes TRLs seven and eight which refer to demonstration projects. These levels are in between knowledge transfer and economic activity.

Table 2.1 There are nine technology readiness levels mainly linking to R&D effort and patenting

TRL	State of Technology	Innovation indicator
1	Basic principles observed and reported	R&D effort
2	Technology concept and/or application formulated	R&D effort, further research
3	Analytical and experimental critical function and/or characteristic proof-of-concept	R&D effort, further research
4	Component and/or Breadboard validation in laboratory environment	R&D effort, further research, possible patent application
5	Component and/or Breadboard validation in relevant environment	R&D effort, further research, possible patent application
6	System/subsystem model or prototype demonstration in a relevant environment	R&D effort, further research, possible patent application
7	System prototype demonstration in a relevant environment	Announcement new product, patenting
8	Actual system completed and qualified through test and demonstration in relevant environment	Announcement new product, patenting
9	Actual system proven successful in operation	Announcement new product, patenting, commercialisation, revenue from new product

Based on a literature review, Perkmann et al. (2012) underline that there is a noticeable difference between academic engagement and commercialisation. Academic engagement is closely aligned with traditional academic research activities and targeted at making resources available to support academic research agendas. Private organisations are more likely to prioritise commercial interests. Therefore, collaboration in the form of a partnership between a public research organisation and a private company is especially important at higher TRLs where commercialisation is important. At lower TRLs, however, public organisations are more important in progressing through the research process and as such to reach the higher TRLs.

2.3 Indicators knowledge valorisation

The level of the knowledge valorisation process can be defined with the help of several indicators. These indicators are based on the available literature and are discussed below. The indicators are roughly divided in two categories: input and output indicators. The input indicators represent factors that facilitate knowledge valorisation and output indicators are a (partially) quantifiable measure of the success of knowledge valorisation.

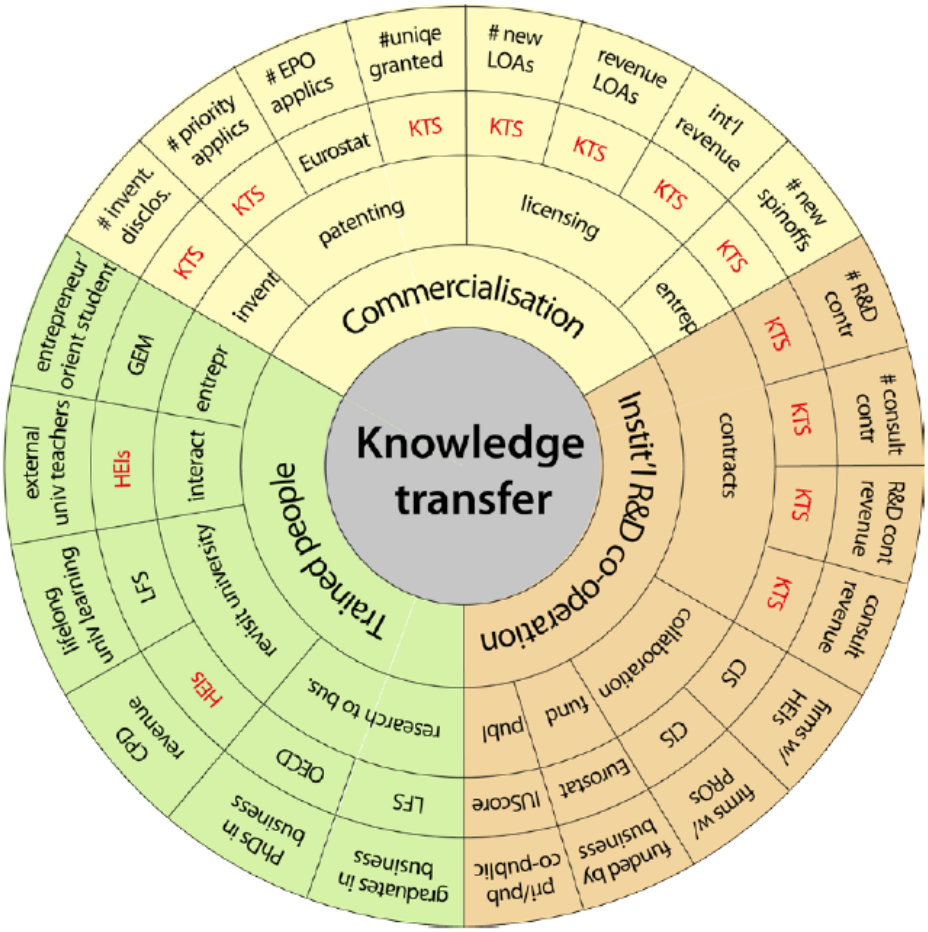
Quantitative indicators

Finne et al. (2011) developed a composite indicator for knowledge transfer/valorisation based on 22 individual indicators. These indicators are categorised in three categories: commercialisation, R&D cooperation and trained people. The indicators are shown in Figure 2.1. Mainly the R&D co-operation and commercialisation indicators are relevant for this study. In Finne's model, the R&D co-operation indicators are input factors and commercialisation indicators are output factors. The main indicators from this figure that may be used to research knowledge valorisation for the TKI Wind op Zee are:

- The number of R&D contracts that Higher Education Institutions (HEIs) and Public Research Organisations (PROs, in the Netherland these are the TO2 institutions) have with firms and other users
- The revenue earned from these R&D contracts
- The number of firms co-operating with HEIs
- Firms co-operating with PROs
- Co-publications between private and public authors
- Invention disclosures from HEI/PRO employees
- (Priority) patent applications
- Patent applications from public sector to the European Patent Office (EPO)
- Patents granted to HEIs and PROs
- International licensing
- The number of spin-offs

These indicators are selected from the composite measure because they fit well to the characteristics of participants in the Wind op Zee projects. Other indicators, such as the number of PhDs and the number of teachers at a university that also have a non-academic job are less relevant for these projects.

Figure 2.1 The composite measure for knowledge transfer is divided into 22 individual indicators



Source: Finne et al. (2011)
Note: HEI=Higher Education Institution, PRO=Public Research Organization, EPO=European Patent Office, KTO=Knowledge Transfer Office, LOA=Licenses, Options, and Assignments, CPD=Continuing Professional Development, LFS=Labour Force Survey , GEM=Global Enterpreneurship Monitor, KTS=Knowledge Transfer Survey, CIS=Community Innovation Survey

The list of indicators as suggested by Finne et al. (2011) is supplemented by Van Drooge et al. (2011). The authors developed a four-dimensional valorisation model in which they describe the most important valorisation indicators for, among others, publicly funded research. The model is four dimensional in the sense that the actors, the aggregation level, the disciplines and the phases in the valorisation process are all considered in defining the set of indicators:

1 **Dimension actors** identifies several types of actors being all responsible for knowledge valorisation. These types are knowledge producers/providers, knowledge users and intermediate parties such as funding agencies.
2 **Dimension aggregation level** refers to the different organisational levels that need to collaborate and are responsible for knowledge valorisation, ranging from the institutional level of universities and funding agencies, the middle management of faculty boards at universities, or R&D departments in companies, and the daily user level of the researchers of the project.

3 **Dimension discipline** acknowledges the fact that different research fields/disciplines might require different valorisation indicators, the indicators may also vary over mono or multidisciplinary research projects.
4 **Dimension phase** underlines that valorisation itself is a process in which awareness and interaction during all phases of the research is important.

Table 2.2 lists the potential indicators per research phase as defined by Van Drooge et al. (2011). For the current review of already completed projects in TKI Wind op Zee, the indicators mentioned in the dissemination and utilisation stage are most relevant. However, for the functioning of the TKI Wind op Zee initiative as such, all indicators are relevant. Indeed, maximising the probability for successful knowledge valorisation requires actions towards valorisation throughout all research phases.

Table 2.2 Indicators per research phase

Phase	Indicator/explanation
Mission	Description of the social and economic mission of the programme
	Description specific goals and measures/conditions/design to achieve these goals
	Commitment of stakeholders in the development of contents and design of the programme
Agenda Setting	Strategical cooperation with organisations focused on knowledge utilisation and valorisation
	Total budget reserved for: intellectual property, translations and other use of results, market research, developing of business plans, exchange of researchers
	Involvement of stakeholders in monitoring the programme
Performance	Explanation how social targets are incorporated in the call, projects and financing
	Explanation how social targets are incorporated in the review of the applications
	The amount of budget reserved for valorisation activities, the percentage of the total budget used for valorisation activities, the percentage applications that utilises these budgets
	Number of projects involving user committees and/or mixed project consortia
Dissemination and utilisation	The number of projects that yield a usable product/process (after completion), the financial value of these products/services
	Number of projects that is continued and co-financed by a stakeholder
	Activities undertaken by programme management to involve stakeholders in the programme. For instance: the number of participants in workshops, events, number of visitors to webpages, number of subscriptions to newsletters

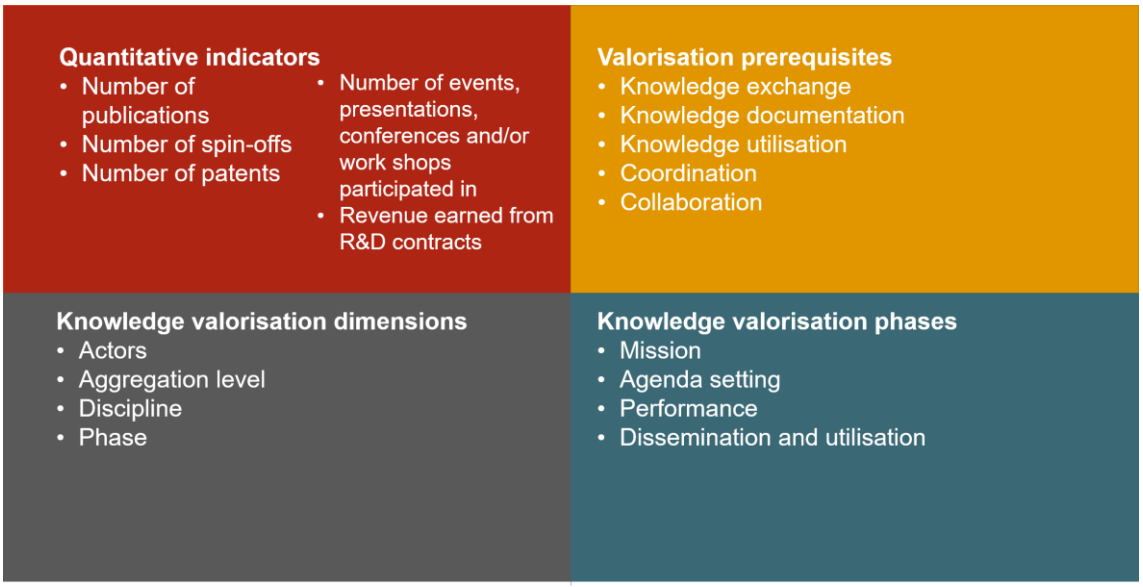
Source: Van Drooge et al. (2011)

To validate the practical relevance of the indicators mentioned by Van Drooge et al. (2011), we look at the 2019 annual reports of all Dutch universities to compare indicators used. Dutch universities focus on a set of valorisation indicators and monitor their performance on these indicators. From the annual reports it follows that all universities have a valorisation strategy and a budget reserved for these activities. The most commonly used indicators to measure the quality of valorisation by Dutch universities in 2019 are: the number of publications, the number of collaborations between universities and companies, the amount of students that find a non-academic job, the number of start-ups and spin-offs and licences and the number of patent applications.

Furthermore, participation in conferences, seminars and workshops are often used as a measure of valorisation activity. These indicators closely match the indicators mentioned in Van Drooge (2011). Most indicators are also part of Finne's (2011) composite measure for knowledge transfer. These indicators are therefore relevant for measuring valorisation in the TKI Wind op Zee initiative.

Figure 2.3 gives an overview of all relevant knowledge valorisation indicators. The upper left panel gives an overview of the quantifiable measure of the success of knowledge valorisation. The upper right panel gives an overview of the prerequisites for successful valorisation. Without knowledge sharing, careful documentation, the direct use of knowledge (utilisation) and the collecting of dispersed pieces of knowledge, the probability of successful valorisation would be limited. The lower left panel gives an overview of the various dimensions of knowledge valorisation. Actors refers to all knowledge producers, users and intermediate parties, the aggregation level refers to all different organisational levels that need to collaborate and are responsible for knowledge valorisation, discipline acknowledges the fact that indicators may vary over mono or multidisciplinary research projects and phase underlines that valorisation itself is a process in which awareness and interaction during all phases is important. The lower right panel gives an overview of the valorisation phases.

Figure 2.3 Overview of valorisation indicators



Source: SEO Amsterdam Economics (2021)

3 Instruments & projects in Wind op Zee

TKI Wind op Zee provides support to research executed via multiple different subsidy instruments and targeted at different levels of technological readiness. The selected projects for explorative analysis include about 70 projects funded through RVO and 100 projects funded through NWO.

3.1 Different subsidy instruments

TKI Wind op Zee is part of the Topsector Energy and facilitates cooperation between private companies, research institutions and government in offshore wind research, innovation and deployment. TKI Wind op Zee focusses on cost reduction and optimisation, integration into the energy system and integration into the environment. The large-scale grants and subsidies are financed by the Ministry of Economic Affairs (EZK) and Climate Policy and the Ministry of Education, Culture and Science (OCW). The resulting programmes funded by EZK are executed and managed by the Dutch Enterprise Agency (RVO), whereas the programmes funded by OCW are executed and managed by the Dutch Research Council (NWO). For all projects, TKI Wind op Zee is involved and closely monitors the research projects. TKI Wind op Zee facilitates in finding partners for a consortium by means of matchmaking workshops and forms.[3]

Table 3.1 shows the different subsidy instruments available for projects in the TKI Wind op Zee programme. Different subsidy instruments may have different targets. The clearest example of such a difference can be seen by comparing the research grants from the NWO and grants from the RVO for more applied research. For the latter, one would expect types of knowledge valorisation more closely related to innovative final products, services or processes. The research grants of NWO typically are targeted at earlier stages of the innovation process. The indicators for knowledge valorisation should therefore also differ.

Instruments of the NWO
NWO contributes to the mission-driven top sector and innovation policy through the knowledge and innovation covenant (KIC). To achieve this, NWO initiates collaborations, establishes links between scientists, private and public parties, and NWO encourages to explore new avenues.[4] The KIC's financial contribution is available for fundamental and practice-oriented research carried out by scientists in collaboration with companies.

In order to contribute to the efficiency of the KIC, NWO organises several matchmaking activities that help organisations to find suitable partners and explore the suitability of research initiatives at an early stage.

Table 3.1 TKI Wind op Zee includes low, mid and high level TRL funded research projects

[3] See https://www.topsectorenergie.nl/tki-wind-op-zee

[4] See https://www.nwo.nl/en/researchprogrammes/knowledge-and-innovation-covenant

Instrument	Type	Project type & level (TRL)	Category
NWO			
Programma Kennis en innovatieconvenant (KIC)	Tender, ranking based	Discovery (Low)	Exploratory Research stimulating private and public collaboration
Nationale Wetenschapsagenda (NWA)	Tender, ranking based	Discovery (Low)	Exploratory Research that serves to connect science and society
Multiple other generic NWO instruments, such as Rubicon and NWO Talent Programme	-	-	-
RVO			
Wind op Zee R&D	Tender, ranking based	Development (Mid)	Development aimed at practical application in 2030 (or soon after).
Hernieuwbare Energietransistie regeling (HER)	First come first serve	Development (Mid)	Development: optimisation and cost reduction. Aimed at higher TRLs.
Demonstratie Energie- en Klimaatinnovatie (DEI+) 2020	First come, first serve	Demonstration & Deployment (High)	Demonstration of new technology or new practical applications or a permanent installation.

Source: SEO Amsterdam Economics (2021) based on https://www.topsectorenergie.nl/tki-wind-op-zee/subsidieregelingen-voor-wind-op-zee

There are numerous calls that are covered by the KIC. Currently, the Innovations for Wind and Solar Energy is the most relevant call for this study. The programme falls within the context of the wider Knowledge and Innovation Agenda (KIA) Energy Transition and Sustainability. The purpose of this wider programme is to contribute to the Dutch National Climate Agreement. The main goals of the specific call are efficiency, cost reduction and the circular design of materials, systems and processes for wind and solar energy. In order to be eligible to receive subsidy in this call, a candidate has to meet the following requirements:

- Besides the main applicant and co-applicant(s), a consortium always consists of two or more co-funders, possibly supplemented by one or more collaborating partners.
- The main applicant should be a full, associate, assistant professor or other researcher with comparable appointment and should be employed at a university or other by NWO appointed research institute.
- All participants must play an active role in the formulation of the research questions and the design and realisation of the project.

- The total budget for a project must be at least €750,000 and at most €1,500,000.
- The maximum duration of a project is six years.

The KIA is a tender-based programme and the applicants will be ranked based on the following criteria: problem posed and problem analysis, contribution to solution, expected impact and route to impact, quality of consortium and the quality of research. NWO assigns a weighting of 30 per cent to the quality of the consortium.[5] By means of this ranking system, NWO tries to ensure public private collaborations which pay proper attention to knowledge valorisation. Knowledge utilisation is a separate budget category for which subsidy can be requested. Each applicant is required to write an impact plan to describe how the knowledge will impact society. The proposal form contains several questions that serve as an initial step towards the impact plan. The instrument does not require the project to be at a certain TRL in order to be eligible for a grant. The requirement of a tenured principal investigator, however, implicitly indicates that lower TRLs are aimed for in this programme.

A second large-scale grant scheme is the Dutch Research Agenda (Nationale Wetenschapsagenda, NWA). The goal of this programme is to provide a positive and structural contribution to the global knowledge society of tomorrow, in which knowledge flows freely from researcher to user. The overarching aim of this programme is to improve the connection between science and society. To achieve this, the NWA programme encourages research relevant for society, facilitates knowledge sharing via interdisciplinary and knowledge-chain-wide collaboration, and proactively involves societal partners in the formulation, setting up and realisation of the research.[6]

There are numerous calls that are covered by the NWA. Currently there is no offshore wind innovation call available, however, the most relevant calls in the past were *Dutch Research Agenda – Theme: Ecology & North Sea* and *Dutch Research Agenda – Theme: Storage and Conversion*. In order to be eligible to receive subsidy in this call a candidate has to meet the following requirements:[7]

- Besides the main applicant and co-applicant(s), a consortium always consists of two or more co-funders, possibly supplemented by one or more collaborating partners.
- The main applicant should be a full, associate, assistant professor or other researcher with comparable appointment and should be employed at a university or other by NWO appointed research institute.
- All participants must play an active role in the formulation of the research questions and the design and realisation of the project.
- The total budget for a project must be at least €600,000 and at most €750,000.
- The minimum duration of a project is two years and the maximum duration is three years.

[5] See https://www.nwo.nl/en/calls/innovations-wind-and-solar-energy

[6] See https://www.nwo.nl/en/researchprogrammes/dutch-research-agenda

[7] See https://www.topsectorenergie.nl/en/nieuws/dutch-research-agenda-theme-ecology-north-sea

Similar to the KIA, the NWA is a tender-based programme and the applicants will be ranked based on the same criteria as in the KIA. Again, knowledge utilisation is a separate budget category for which an applicant can request a subsidy. An impact plan is required in order to apply for a grant. As holds for KIA, there are no explicit requirements for TRL in the NWA calls. The requirement of a tenured principal investigator, however, implicitly indicates that lower TRLs are aimed for in this programme.

Instruments of the RVO

The table includes three instruments directly administered by the RVO. The Wind op Zee R&D instrument is aimed at cost reduction and optimalisation, storage and conversion and environmental integration of offshore wind energy. To do so, the programme is aimed at projects with a mid-level TRL and practical application of new knowledge/technologies in 2030 (or soon after). The Wind op Zee R&D programme is a tender programme. This implies that the applications will be carefully evaluated by an external team of reviewers. The subsidy will be granted

to the projects with the highest rating. To be eligible to receive subsidy through this programme, the following requirements hold:

- The project must be executed by a partnership consisting of at least 1 private organisation.
- RVO must be able to keep track of the progress throughout the entire duration of the project.
- Total investment must lie in between €2 million and €4 million, at least €25,000 per partner.
- Research organisations (universities/TO2) may not be responsible for more than 65 per cent of the total investment.

The ‘Missiegedreven Onderzoek Ontwikkeling en Innovatie’ (MOOI) programme replaced the RVO R&D programme in 2020. The main difference is the focus on an integral approach. For the MOOI programme, the partnerships must consist of at least three innovative SMEs and stakeholders. The partnerships co-operate in finding integral solutions to challenges as defined by the climate agreement.

The ‘Hernieuwbare Energietransitie Regeling’ (HER+) instrument is aimed at granting subsidy to partnerships that execute innovative projects that result in CO_2-reduction in 2030. The HER+ programme is designed to achieve the climate goals and reduce the CO_2-emissions by 2030. There is no requirement for a collaboration in the form of a partnership between a public research organisation and a private company. The HER+ programme is a fully first come, first serve regulation implying that each project that fulfils all basic requirements will receive the grant requested up and until the budget is exhausted. The HER+ programme is aimed at projects with a mid-level to high-level TRL and at optimalisation and cost reduction. To be eligible to receive subsidy through this programme a candidate has to meet the following requirements:

- The project must be executed by a partnership consisting of at least 1 private organisation.

- The partnership must be balanced, meaning that both the investment and the effort must be shared proportionally.
- It is not allowed to have over 50 per cent of the investment used to hire third parties.
- The expected cost reduction from the project must exceed the subsidy required.

The 'Demonstratie Energie en Klimaatinnovatie' (DEI+) is aimed at granting subsidy to partnerships that are demonstrating innovative technologies that are aimed at reducing energy consumption and CO_2 emissions. In this manner, DEI+ should contribute to the climate goals. Similar to the HER, the DEI+ programme does not require a public private partnership. The DEI+ is a first come, first serve programme. The applications are carefully evaluated by a team of experts in terms of technical and financial feasibility and the subsidy will be distributed to the earliest applicants up to and until no budget is left. The subsidy will be granted to the projects with the highest rating. DEI+ is aimed at projects with a high-level TRL. The programme focusses on the demonstration of projects and/or practical application rather than developing new knowledge/technologies. To be eligible to receive subsidy through this programme, a candidate has to meet the following requirements:

- The project must be executed by a partnership consisting of at least 1 private organisation.
- The partnership must be balanced, meaning that both the investment and the effort must be shared proportionally.
- The duration of the project is at most 4 years.

Concluding remarks regarding available instruments
Both RVO and NWO already focus on key elements of knowledge valorisation in their regulations:

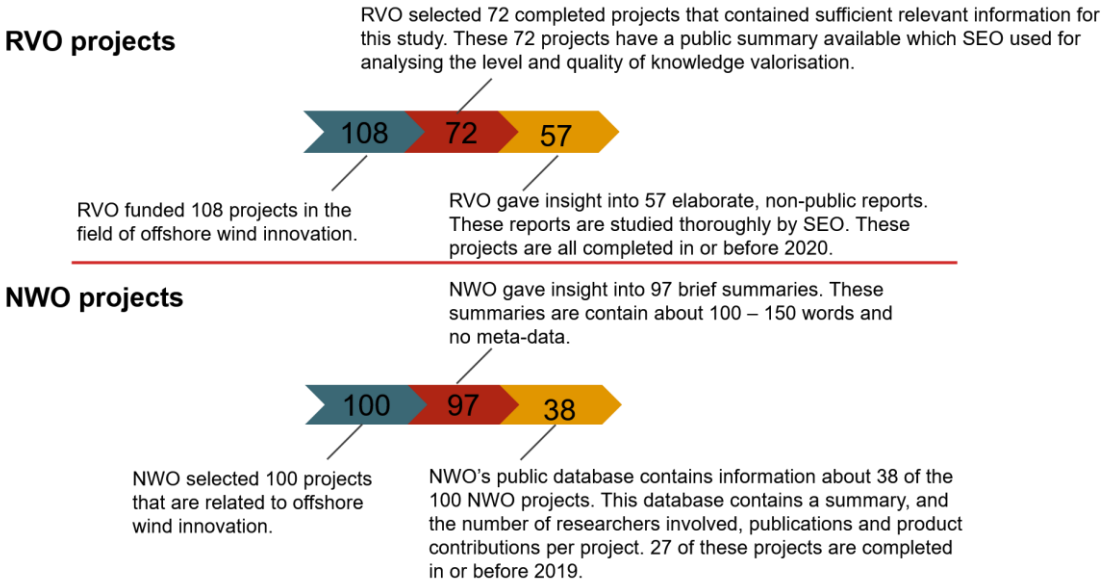
- Both RVO and NWO mainly select research projects eligible for funding based on tendering.
- The quality of a consortium is an important part of the quality assessment of a proposal.
- NWO requires an impact plan for each proposal.
- Collaboration in the form of a partnership between a public research organisation and a private company is not a pre-requisite in the RVO/NWO's regulations, however, this type of partnership is actively stimulated by both RVO and NWO.

From the literature review in Chapter 2 it follows that the type, intensity and frequency of collaboration is a key driver of successful knowledge share. The focus on the quality of the consortium seems therefore appropriate. The same holds for requiring principal investigators to formulate an impact plan at the beginning of the research process. The focus on public-private collaborations is also in line with the key determinants for successful innovation as is known from previous research. This type of collaboration increases the probability that within one research project researchers focusing on low TRLs and ones focusing on higher TRLs are active.

3.2 Selection of projects for explorative analysis

The public database by TKI Wind op Zee only includes information about the research projects administered by RVO. Some of the projects administered by NWO are included in NWO's online database. Figure 3.1 gives an overview of the selection of projects.

Figure 3.1.1 Selection of RVO and NWO projects



Source: SEO Amsterdam Economics (2021)

The explorative analysis looks at completed research projects only. Furthermore, we look at successfully completed projects. Successfully here refers to projects that received the total amount of subsidy before the anticipated start date of the research project. In other words, we look only at those projects that received the means to start the research process and execute the work as proposed. To obtain information about these research projects we received additional material from both RVO and NWO.

RVO provided data on 72 offshore wind innovation projects that are relevant for an explorative analysis of knowledge valorisation and match the above-mentioned conditions. Summary reports for all 72 projects are examined, in addition, more detailed reports for 57 projects are available and also taken into consideration. Both reports are included in the explorative text analysis.

NWO provided data on 100 offshore wind innovation projects that are relevant for an explorative analysis of knowledge valorisation and match the above-mentioned conditions. These 100 projects have a public summary available. No other reports are available. NWO's online database contains more details about 38 of these 100 projects.

All principal investigators of the above mentioned 172 projects are requested to participate in an online survey about knowledge valorisation.

4 Explorative analysis selected projects

Most of the reports mention knowledge valorisation. The results of the online questionnaire suggest high levels of valorisation with 95 per cent indicating that the research led to new products, processes and/or services. Inclusion of a public partner into the research programme is often mentioned as an important enabler of knowledge valorisation.

4.1 Meta-data selected projects

Table 4.1 gives an overview of the meta-data on the selected project from both RVO and NWO. A one-to-one comparison of this meta-data between projects administered by the two organisations is only possible for a few key variables. In particular, only for the average duration and the average number of parties/researchers involved data is readily available for both RVO and NWO. These indicators seem to be rather similar between the two organisations. Below we briefly discus the meta-data per administrative organisation.

Table 4.1 The availability of information on potential key indicators differs between RVO and NWO administered research projects

	RVO	NWO
Number of projects and duration		
Total number of TKI Wind op Zee research	108	100
Number of research projects selected for this study	72	100
Number of public summaries available	72	38
Number of non-public reports (RVO) / non-public summaries (NWO)	57	97
Number of projects with additional information available	57	38
Average duration of research project (years)	2	3
Collaboration & TRL		
Average number of parties (RVO) / researchers (NWO)	4	3
Number of research project including public actor	44	100
Average TRL (1-9)	5	-
Subsidy		
Average total investment per research project	€ 966.000	-
Average total subsidy per research project	€ 531.000	€ 400.000
Average share of subsidy (unweighted)	57 %	-
Output		
Average number of publications per research project	-	4,8
Average number of contributions to new products	-	2,4

Source: SEO Amsterdam Economics (2021)

RVO data

At the time of this research, there are 108 completed research projects available in the public database of TKI Wind op Zee. These projects only include the ones administered by RVO. From these projects, RVO provided meta-data on 72 projects. This information is summarised in table 4.1 above. For the remaining research projects, RVO does not have sufficient information available. This prevents us from including these remaining research project into the current analysis.

The average duration of research projects administered by RVO is about 2 years. The duration is calculated as the difference between the start date and the date of completion according to RVO's available data. The majority of projects is situated at a mid-level TRL. The average TRL is 5. This is in line with expectation because RVO is responsible for more applied research projects as compared to NWO.

The average total investment of an RVO project is €966,000. The average project received on average an amount of €531,000 in subsidy. This implies that, on average, a project receives about 57 per cent of the total investment as subsidy. Based on the data provided by RVO, we can disentangle total project budget into different categories. RVO distinguishes the categories Personnel, Machinery, Material and Third Party. On average, these categories make up for 76, 6, 5 and 13 per cent respectively. The majority of the research budget hence is allocated to labour/personnel.

51 of the projects are part of the Wind op Zee R&D tender (or predecessors), 20 projects belong to the 'Hernieuwbare Energietransitie' programme and 1 project belongs to the 'Demonstratie Energie- en Klimaatinnovatie' (DEI+) programme. The 72 principal investigators of these projects are invited to participate in an online questionnaire. The results of the questionnaire are then matched to the database as described above. This allows for examining correlations between characteristics of the research project and outcomes of knowledge valorisation.

NWO data

At the time of this research, NWO identified 100 research projects related to offshore wind innovation projects, hence related to the TKI Wind op Zee programme. According to NWO, the majority of these projects are completed, however, there are only 38 projects that have information about the end date available. 27 of these 38 projects are completed in or before 2019. NWO provided additional information via 97 project summaries.

The meta-data regarding the NWO administered research projects is also included in Table 4.1. NWO gave SEO insight into some of the meta-data of the 97 selected projects. The amount of subsidy received varies between €10,000 and €1.5 million with an average of €0.4 million per project. About 50 per cent of these projects received co-funding from a private company. The co-funding is equal to 20 – 25 per cent of the total project's investment. The other meta-data in Table 4.1 is based on the 38 out of 97 research projects that have been analysed via the public online NWO database. This database contains information about the start- and end date, the duration of the project, the number of researchers involved and the output in number of publications and contributions to new products. These 38 projects have an average duration of about three years, an average of three researchers involved, about five publications on average and 2.4 contributions to new products per project. When looking at research projects finished in or before 2019 only, the average output is, as anticipated, slightly higher with about 5.3 publications and 3.2 contributions to new products.

It is not clear at which TRL the NWO projects are situated, however, the principal investigators are always tenured. Therefore, it is expected that most projects are situated at a lower TRL and are mainly focussed on explorative research.

The 100 NWO projects are branched over a wide variety of NWO calls. The largest category, 15 projects, belongs to the call named 'Rekentijd Nationale Computersystemen'. The 100 principal investigators of the selected projects were invited to participate in an online questionnaire. NWO did not disclose the participants of the online questionnaire. Therefore, we are not able to match the database

information to the outcomes of the online questionnaire. The NWO data is used to identify the level of knowledge valorisation in the NWO projects by means of descriptive analysis. The public database contains 27 projects that are completed in or before 2019. These projects are statistically analysed for an association between the number of publications and the quantity of research output.

4.2 Methods of explorative analysis

Text analysis of publicly available databases
The 72 public summaries of projects provided by RVO, the additional 57 accompanying final reports and the 97 public summaries of the NWO offshore wind innovation projects are all manually scanned for keywords related to offshore wind energy innovation. Table A.1 in Appendix A gives an overview of keywords used to scan all reports. In 19 per cent of the public summaries of RVO projects at least one key word related to knowledge valorisation has been found. Only in 6 per cent of the NWO projects at least one key word has been found. The 57 final RVO reports are much more substantive and extensive. In the vast majority of the final reports, 91 per cent, at least one key word has been found. The results of the scanning process for these reports are shown in Table A.2 in Appendix A.

The public NWO database contains information about 38 of the 100 by NWO selected projects. These projects were manually searched and thoroughly studied for the quality of knowledge valorisation in these projects. 19 of the 38 projects published at least one article in a scientific journal and 13 of the 38 projects contributed to developing innovative products. The average number of publications of the 38 observed projects is about 5.

Supplementary questionnaire RVO administered research projects
Supplementary to the analysis of available databases, an online questionnaire on the level and quality of knowledge valorisation in TKI Wind op Zee projects has been executed. All principal investigators from the by RVO and NWO selected projects were requested to participate in this online questionnaire.

The 172 invitations led to 42 complete responses. RVO has a high response rate of 46 per cent, whereas NWO has a response rate of 9 per cent. A possible explanation for this lower response rate could be that NWO did not send more than one reminder to the principal investigators. SEO sent several reminders to the principal investigators of RVO administered projects.

4.3 Main insights from explorative analysis[8]

Descriptive analysis
The principal investigators represent three kinds of organisations. 55 per cent of the respondents represent a private organisation, 21 per cent represents a research

[8] Appendix B shows additional figures and results of the survey regarding the dimensions and insights mentioned in this section.

institute and 21 per cent represents a university.[9] All the NWO respondents are working at a university, whereas none of the RVO respondents do.

A key indicator of knowledge valorisation is defining a knowledge valorisation strategy prior to the start of the project. 76 per cent of the respondents indicate that their project plan included a section on knowledge valorisation. This is a substantive number and indicates that knowledge valorisation plays a role in these projects. The number of respondents indicating that knowledge valorisation is part of the project plan is proportionally equal over RVO and NWO administered projects and the type of employer of the principal investigator.

Most respondents indicate that participation in presentations, both scientific and non-scientific publications and attending conferences are part of the knowledge valorisation strategy. Only 22 per cent of the respondents indicates at the start of the project that they strive to obtain intellectual property rights. The respondents were asked to indicate, if applicable, the reasons of failure of knowledge valorisation. This open question returned a variety of answers. The most common ones are summarised as follows:

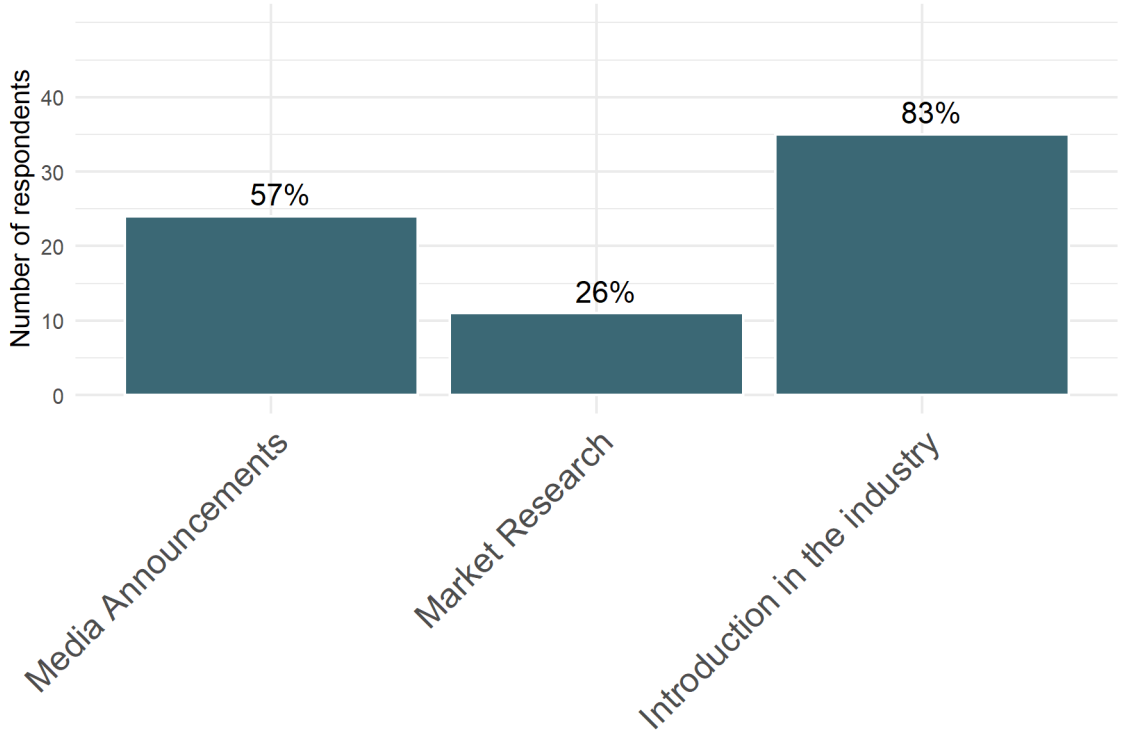
- The private parties gained knowledge; however, they did not decide to further develop it as part of their business.
- The further development of the knowledge became too expensive.

Literature indicates that the likelihood of successful knowledge sharing will be higher if the goal of the project is to have a social impact rather than an economic impact. As anticipated, most principal investigators employed by private organisations indicated that the economic impact is most important. Researchers employed by universities and research organisations mostly answer that the social impact prevails or that the social and economic impact is of equal importance. For research projects with a public-private collaboration, 50 per cent of the principal investigators indicated economic impact prevails over societal impact. This might indicate that the private parties' interests are rather substantive in a mixed consortium.

Figure 4.1 gives an overview of the knowledge valorisation activities that actually took place during the project or shortly after. The most common activity to disseminate knowledge is via introduction of their knowledge in the industry. About 83 per cent of the respondents indicate to use this activity. Taking into account that most of these research projects are situated at mid-level TRLs, sharing about 83 per cent of the research outcomes with the industry increases the likelihood of achieving higher TRLs in the future. In addition, 57 per cent of the respondents indicate that they published at least one article during or shortly after finishing the research project. 7 per cent of the respondents indicate they did not undertake any of the mentioned activities. Other activities that are reported by respondents are: organising seminars, written reports, press releases, actively contacting potential clients, utilise the knowledge in new projects with new partners and spreading the new knowledge via the local government.

[9] 1 respondent preferred not to answer this question.

Figure 4.1 Dissemination within the industry is the most used activity to stimulate knowledge valorisation (42 respondent)



Source: SEO Amsterdam Economics (2021)

Focussing on publications, the survey results indicate that 93 per cent of the respondents already published or are going to publish an article in the near future. The respondents indicate 6 articles on average. The majority, 60 per cent, of these principal investigators are employed by a research institute or university. The results suggest that these types of projects are more likely to yield output in articles compared with research projects led by principal investigators employed by private organisations. Inclusion of a public participant may therefore be beneficial to knowledge sharing activities.

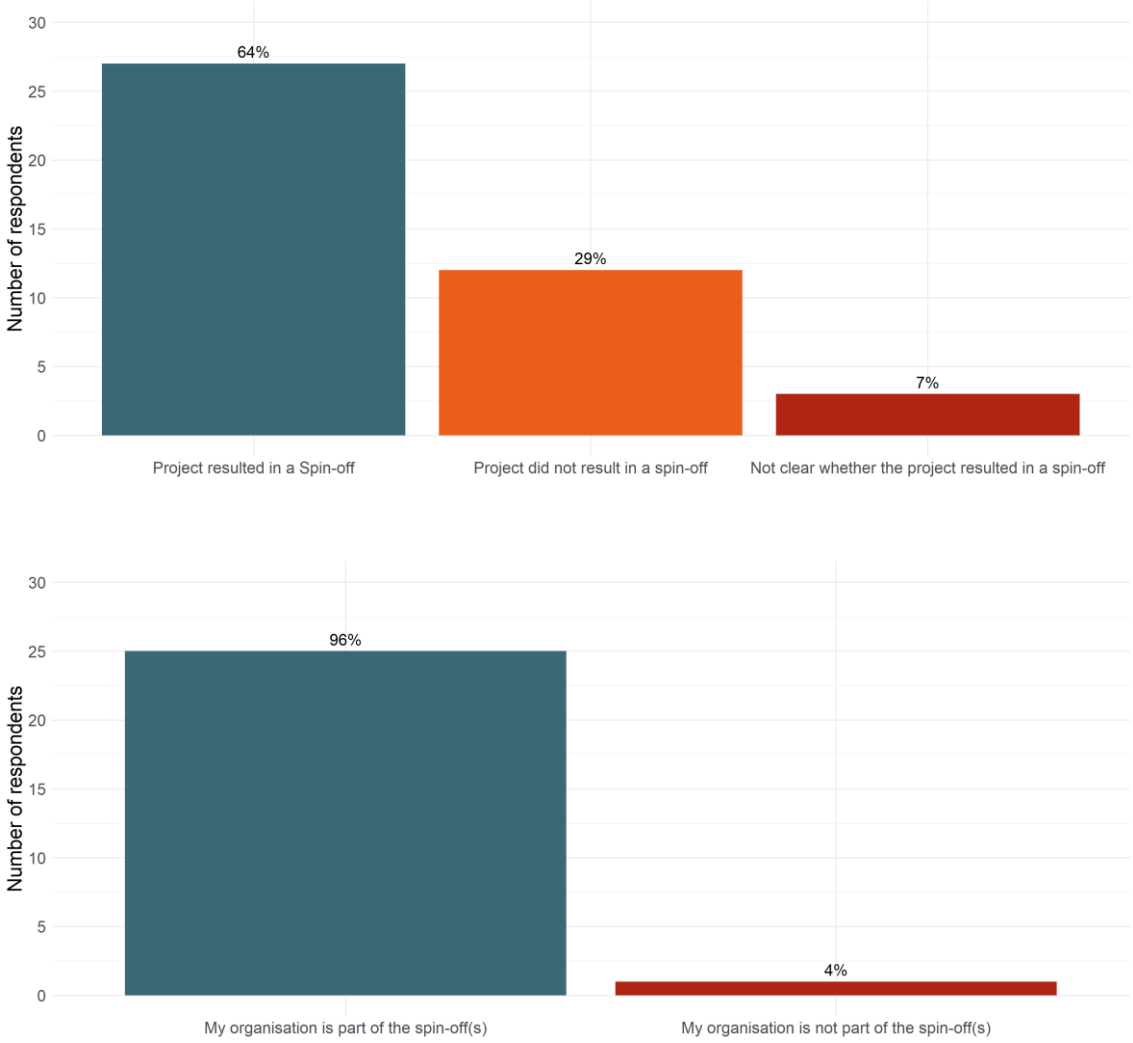
Over 52 per cent of the projects consist of a collaboration between a public participant (university/TO2 institution) and a private participant (company). Exclusive private and exclusive public collaborations occur in respectively 43 and 5 per cent of the cases. This is in line with RVO and NWO guidelines. The assessment of the research proposals takes into account the quality of the consortium and effort on collaboration. As mentioned earlier, the collaboration between public and private parties is beneficial regarding knowledge valorisation. 93 per cent of the respondents indicate that the collaboration helped to share knowledge. The remaining 7 per cent did not find the collaboration useful. All these latter respondents led a research project with a public-public collaboration. This might indicate that in particular public–private collaborations are regarded as being more helpful to share knowledge and achieve higher TRLs.

The upper panel in Figure 4.2 shows how many of the research projects resulted in spin-off activities. For 64 per cent of the research projects spin-off activities are mentioned. The following spin-off activities are mentioned:

- Trying to take a supporting technology to a higher TRL
- Use the developed knowledge in a demonstrating project
- Further research to improve the developed technology
- Exploring commercialisation opportunities
- Possible patent applications
- Research on new application of a comparable technology
- Entering and opening a new market (commercialisation)
- Continuing to make information available for knowledge sharing purposes

The lower panel in Figure 4.2 indicates that in the vast majority of these spin-off activities the principal investigator is involved.

Figure 4.2 The majority of projects resulted in spin-off activities, in almost all cases the principal investigator was part of this activity (42 respondents)



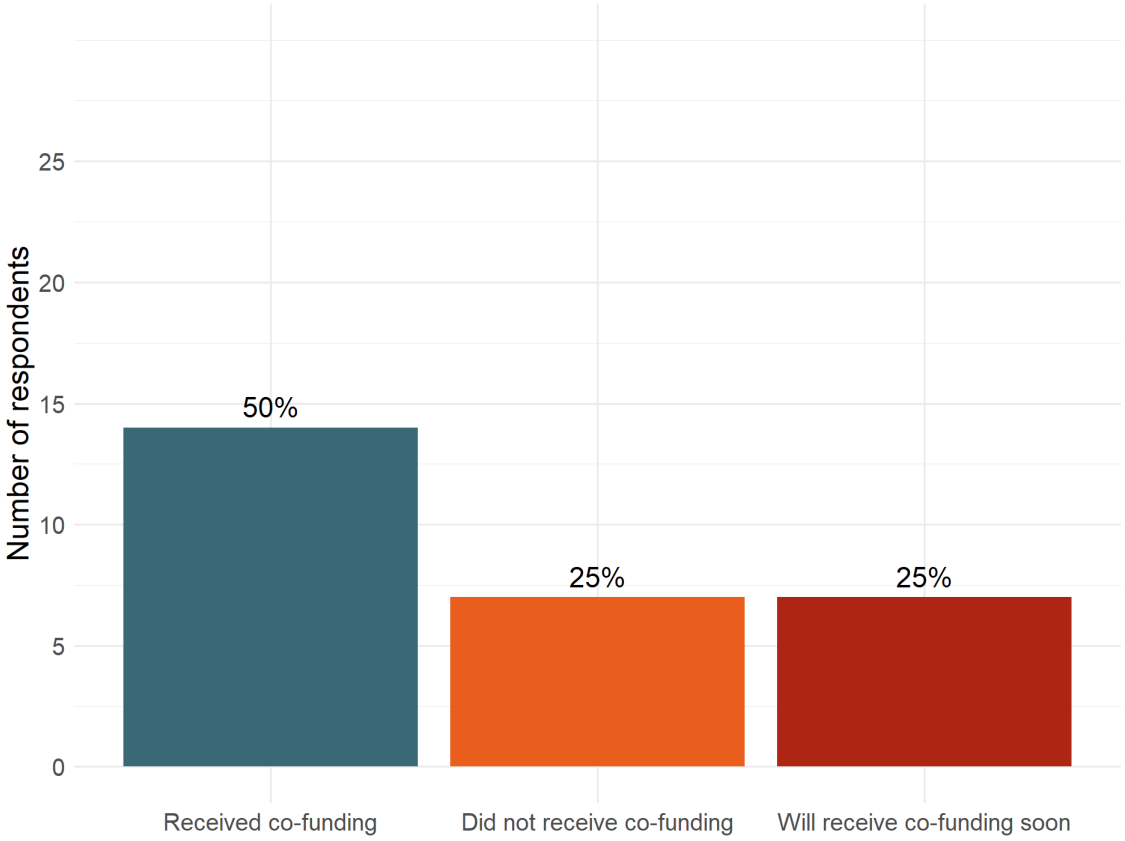
Source: SEO Amsterdam Economics (2021)

Figure 4.3 shows that 50 per cent of the research projects already received co-finance from private organisations. Another 25 per cent expects to receive such funding in the near future based on the current research. Please note that these percentages are based on 28 respondents answering the accompanying survey question. One might assume that respondents not answering this question did not receive co-finance. The percentages would change accordingly to 33 and 17 per cent respectively. Hence, the percentage of projects receiving co-finance as measured of the total sample ranges from 33 to 50 per cent. Both RVO and NWO stimulate and support grant recipients to find private co-funders. The inclusion of private co-funders in a project that generated new knowledge is beneficial for commercialisation purposes. The range from 40 to 75 per cent of co-financing is therefore an important key performance indicator for the large-scale grants and subsidy programmes in this field.

Patent applications are another important indicator of knowledge valorisation. 27 per cent of the respondents indicate that they applied for a patent or will do so in the near

future. This 27 per cent (more or less) matches the 22 per cent of the respondents that indicated they planned to request intellectual property rights before the start of the project.

Figure 4.3 Half of the research projects already received co-financing (28 respondents)

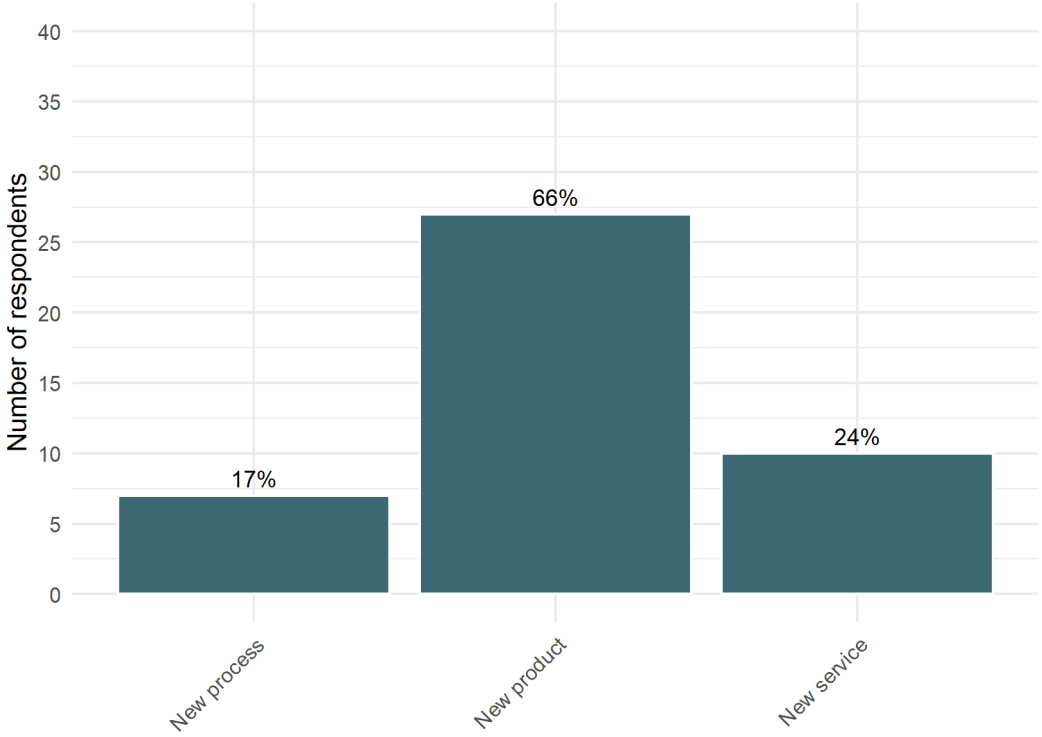


Source: SEO Amsterdam Economics (2021)

Figure 4.4 shows the output of the research projects. There are three categories specified: processes, products, and services. Out of 42 projects, only 2 projects (5 per cent) did not result in any kind of knowledge valorisation as measured via these three categories. A success rate of 95 per cent can be considered (very) high. The most common output is a new product, 66 per cent resulted in the introduction of such a new product. New services and processes were introduced in 24 and 17 per cent of the projects respectively. Reasons for not producing any output include:

- The project was not economically viable after analysis.
- The project did not result in a product/service/process ready to enter the market.

Figure 4.4 The majority of research projects resulted in new products (42 respondents)



Source: SEO Economic Research (2021)

Correlation between different dimensions

This section gives an overview of the results of a correlation analysis of the data available from the online questionnaire combined with the available data from RVO projects. The NWO projects are not included in most of this analysis as we do not have the means available to link the available NWO data to survey outcomes. The following analysis contains data about 33 RVO projects.

This section tests the correlation between project characteristics and indicators of the success of knowledge valorisation in order to find out whether projects with certain characteristics are more likely to succeed in their valorisation mission. The characteristics of the projects included in this analysis are as follows:

- Percentage of subsidy received of the total investment
- Size of the consortium
- C1-ratio[10]
- Herfindahl-Hirschman Index[11]
- Percentage budget reserved for valorisation activities
- Duration of the project

As measures of successful knowledge valorisation, we employ the following:

[10] This ratio is equal to the percentage of the subsidy amount that is received by the largest participant.

[11] This index shows the concentration of the subsidy amount amongst partners in the research project. The higher this index the less proportional the subsidy is divided. The index is calculated as the sum of the squared share of subsidy each participant receives.

- Total number of publications related to the project
- Total number of spin-offs that resulted from the project
- Whether or not follow-up research is conducted
- Total number of patent applications that resulted from the project
- Grand total of number of innovation outputs (products/services/processes)
- Number of events in which the project is presented

Figure 4.5 shows the correlation matrix between the aforementioned dimensions for the 33 projects. The resulting correlations between project characteristics and knowledge valorisation indicators are rather weak and the vast majority is also not statistically significant at a 5 per cent significance level.[12] There are some statistically significant correlations between project characteristics. For example, the size of the consortium is negatively correlated to both concentration indicators. This implies that for a larger consortium, subsidies are more equally divided amongst the participants.[13]

[12] The significant correlations are bold.

[13] As anticipated, the two measures of concentration are highly correlated.

Figure 4.5 The correlation between type of research projects and indicators of knowledge valorisation is low and not statistically significant at a five per cent level (33 respondents)

	Percentage subsidy of total investment	Consortium size	C1 ratio	Herfindahl index	Percentage budget for valorisation activities	Duration	Number of publications	Number of spin offs	Follow-up research	Patent application	Number of innovation output	Number of events
Percentage Subsidy of total investment	1											
Consortium size	**0,24**	1										
C1 ratio	**-0,26**	**-0,62**	1									
Herfindahl index	-0,23	-0,67	**0,98**	1								
Percentage budget for valorisation activities	-0,09	-0,12	-0.13	-0,05	1							
Duration	0,13	**0,44**	**-0.30**	**-0.34**	-0,31	1						
Number of publications	-0,28	-0,18	0,45	0,41	-0,29	**-0,50**	1					
Number of spin offs	-0,02	0,15	-0,12	-0,03	0,09	-0,04	0,33	1				
Follow-up research	0,22	0,13	-0,08	-0,06	-0,05	0,04	0,13	0,1	1			
Patent application	0,03	-0,15	0,17	0,18	0,22	0,03	0,04	-0,05	-0,04	1		
Number of innovation output	0,23	-0,15	0,06	0,02	-0,04	0,16	-0,02	-0,13	0,13	-0,09	1	
Number of events	-0,27	0,15	-0,18	-0,17	0,27	-0,01	0,11	0,27	0,30	0,17	0,08	1

Source: SEO Amsterdam Economics (2021)

Duration of a research project shows some correlations with other dimensions. The size of a consortium and the duration are positively correlated, implying that for a larger consortium the duration of the research project is longer. In addition, and in line with the above relation between consortium size and concentration, longer projects also imply more equally divided subsidies. The most surprising result is that longer projects are negatively correlated with the total number of publications. Potential cofounding reasons for this finding include that longer projects are more risky and/or complicated or that longer projects are completed more recent and therefore working papers may not be published yet. Except for the surprising finding between duration and number of publications, there are no clear patterns between indicators and project characteristics identified. Potential causes for the lack of significant correlations are:

- The analysis contains only 33 datapoints.
- There are other, non-observed factors that influence the indicators of valorisation more heavily than the observable project characteristics, or the other way around.

- There may be a discrepancy in the understanding of the questionnaire by the different principal investigators.[14]
- There is no uniform method of reporting output. All projects are required to deliver a final report without predefined definitions.

We analysed the available information about 30 completed NWO projects available in the NWO public database. As mentioned earlier, the average number of publications in these projects is 4.8 and the average research output is 2.4. There exists a significant positive correlation of 0.59 between the number of publications in a NWO project and the number of research output. This correlation is significant at the 5 per cent significance level. Hence, there seems to be a positive association between the number of publications and the number of research output in NWO projects. This result is not surprising because both are indicators of success and one such a success may result in both publications and contributions to new products.

Main takeaways of the survey

The main findings from the online questionnaire are:

- Already 76 per cent of the RVO/NWO subsidy applicants are writing a priori plans related to knowledge valorisation.
- There is no evidence that certain types of principal investigators are more likely to define knowledge valorisation in the project plan.
- Principal investigators find a collaboration in the form of a partnership between a public research organisation and a private company most beneficial for knowledge sharing.
- 52 per cent of the projects consist of a public-private collaboration, which is perceived the most beneficial partnership for knowledge sharing purposes.
- Principal investigators indicate that in most cases the public participant was at least as important or more important in contributing to the generation of new knowledge.
- 64 per cent of the projects have resulted in spin-off activities, the new activities include further research, trying to achieve higher TRLs and/or commercialisation.
- 75 per cent of the projects already received or will receive co-financing from a private company.
- 93 per cent of the respondents indicated that their project resulted in a publication.
- 95 per cent of the projects yielded in a (contribution to a) new product, service or process.
- The statistical analysis did not show significant correlations between any of the project characteristics and the valorisation indicators.
- There seems to be a positive association between the number of publications and the number of research output in 27 NWO projects that are completed in or before 2019.

[14] By including a list of definitions in the online survey we mitigated this potential issue, but different interpretations might still play a role.

5 Conclusion & discussion

Knowledge valorisation takes a prominent position in research projects in the field of TKI Wind op Zee. Assessment criteria of different funding alternatives are in line with important drivers of knowledge valorisation as known from the literature. The projects seem to be rather successful in valorisation, however, differences in (meta-)data quality and availability of project reports prevent statistical testing of hypotheses.

Research question(s)
This study aims to measure the level and, if possible, quality of knowledge valorisation in the research projects that are in scope of the TKI Wind op Zee programme. To answer this question, the following sub questions are considered:

1 To what extent do completed research projects in the TKI Wind op Zee programme show success in innovation and applicable knowledge?
2 What are the main drivers for the degree of successful innovation and knowledge valorisation?
3 What are the main impediments preventing knowledge valorisation from being created?
4 Are there any differences between types of subsidy programmes and knowledge valorisation?

Sub question 1 - success in knowledge valorisation
Knowledge valorisation refers to the process of making scientific/academic research available for practical use. The most commonly used indicators of the quality of knowledge valorisation are the number of (scientific) publications, licences and patents, spin-offs, non-academic jobs created and revenue generated from newly generated knowledge. These indicators are also used by Dutch universities in 2019 to evaluate the quality of their valorisation activities.

The outcomes of the online questionnaire suggest a high level of valorisation in the projects subsidised by RVO/NWO in the context of the TKI Wind op Zee programme. The majority of the principal investigators indicated they come up with a valorisation plan before the start of the project. Even more striking is that for the RVO administered research projects, 95 per cent of the principal investigators indicate that the research resulted in a new product, service or process that can be utilised for future research/projects.

Sub question 2 - main drivers for knowledge valorisation
There is a consensus in the literature that knowledge exchange, precise documentation, knowledge utilisation, coordination and collaboration are the most important prerequisites of successful knowledge valorisation. Knowledge valorisation plays an important role throughout the entire innovation process. The innovation process starts at lower TRLs in which exploratory research and knowledge sharing activities are most important. At higher TRLs commercialisation and public-private collaborations are the most important stimulus of knowledge valorisation.

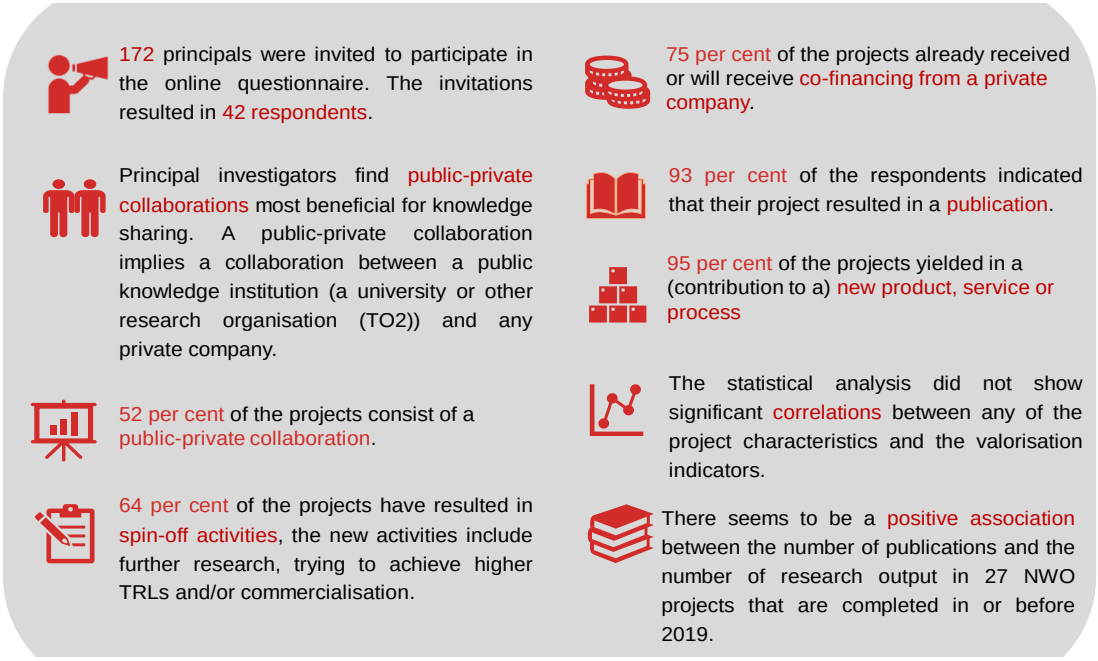
From the online survey follows that the inclusion of a public partner (university/TO2) is found to be beneficial in terms of the generation of new knowledge and knowledge sharing purposes. However, the public-private collaboration seems to be the most efficient collaboration with respect to knowledge valorisation. Hence, the role of the private participant is important. Especially at valorisation activities in higher TRL projects the role of the private participant is significant. These activities are often linked to commercialisation.

Sub question 3 - main impediments regarding knowledge valorisation
Besides mirroring the answers to sub question 2, the online survey yielded two reasons for not achieving any knowledge valorisation. The first one mentioned is that during or after the research project, the product, process, or service is not economically viable. The second reason mentioned is that the product, process, or service was not ready to enter the market. It is often mentioned that further research is required. The latter impediment might be a temporary one, further research might improve the output into an economic viable output, whereas the former has a more final character.

Sub question 4 - differences across instruments and/ or types of research
The resulting correlations between project characteristics and knowledge valorisation indicators are rather weak, and the vast majority is also not statistically significant at a 5 per cent significance level. There are some statistically significant correlations between project characteristics.

Insights from survey
Figure 5.1 gives an overview of the main takeaways from the data analysis and the online survey. These give an insight into the current level of knowledge valorisation in TKI Wind op Zee projects.

Figure 5.1 Overview of takeaways data analysis and survey results



Source: SEO Amsterdam Economics (2021)

Discussion and recommendations

Measuring a rather intangible concept as knowledge valorisation is not easy. The available literature, as summarised in Chapter 2, gives a list of quantifiable indicators. This explorative study clearly shows that knowledge valorisation is very well institutionalised at the start of the research process. Valorisation is one of the assessment criteria. However, the (meta-)data search in this explorative study also shows that monitoring on and reporting about knowledge valorisation is much less institutionalised and strictly depends on organisations and individuals (the members of research teams) to co-operate. To get a better empirical understanding of the strengths, weaknesses and opportunities for innovative research and possible threats, a better coordination on monitoring and gathering data from completed research projects is essential.

In particular, because these research projects receive public funding, one would expect and require a more standardised way of reporting on outcomes. Arguments that such standardised systems would focus on quantity instead of quality do not take into account that measuring quality insights in quantities is needed. Indeed, a simple count of a total number of products should be a starting point for introducing the quality dimension.

The empirical study shows that final reports are not available for many completed research projects or are very short. For example, from the approximately 100 administered projects by NWO, only about 40 per cent of these are available in the NWO online project database. Also, RVO had to select projects because for multiple projects the information was not sufficient to be included in this study. From the perspective of TKI Wind op Zee, and in general, it would be beneficial for a top

consortium if administrative data availability, whether being public or not, does not depend on the administrative organisation.
In particular, when (administrative) datasets are not available or made accessible to researchers, facilitating the contact between the researchers and the principal investigators of the completed research projects should be a priority. In this light, the decision by NWO, in contrast to RVO, not to facilitate reminders of the survey and the link between the research projects was counterproductive in building a strong knowledge on the success of valorisation.

Below we summarise our **recommendations**, both from the perspective of the content as well as from the perspective of the process:

- Both the literature and the survey results underline the importance of public-private collaboration to achieve knowledge valorisation in innovative (applied) research at mid-range TRLs. In the current funding instruments by both RVO and NWO, a public-private collaboration is not a prerequisite, whereas the results of this analysis show that this would increase the chance of a successful knowledge valorisation.
- To achieve a more structural insight on knowledge valorisation, monitoring of the research projects near and after completion should be improved upon. The administrative agencies should develop a list of essential questions on knowledge valorisation based on the assessment criteria and indicators of knowledge valorisation. Together with delivering a public summary, answering the list of essential questions should be compulsory for principal investigators.
- Research and valorisation do not stop at the end of a research project, in particular the successful ones. However, it is currently impossible to follow research from a certain research group or consortium over time or over different research projects. In the online survey, a large share of principal investigators indicated to continue the research via either co-financing or new research proposals. Ideally, one would be able to follow a research idea to progress via different research projects through the different TRLs. A possible way to achieve this is to annually or bi-annually keep in contact with the principal investigators of completed research projects with the same type of survey as mentioned in the previous recommendation.
- It would be helpful if all projects are required to deliver a final report of which the format is pre-specified. This would help in terms of the interpretation of what is precisely meant in the valorisation activities sections. There are numerous different terms used for similar activities in the final reports studied. Furthermore, it would require all projects to deliver a list of publications, research output, etc.
- Developing a benchmark for expected output of research projects, in for example number and quality of publications, etc. would help in evaluating and learning from the wide range of research projects.
- Besides setting up a monitoring or data gathering system for the more quantifiable indicators, discuss how to measure the quality of knowledge innovation.

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Appendix A Results and text analysis

Table A.1 The final reports are scanned for a set of about twenty keywords

English	Dutch
Spin-offs	Spin-offs
Publications	Publicaties
Presentations	Presentaties
Thesis	Scriptie
Conference	Conferentie
Further Research	Vervolg Onderzoek
Valorisation	Valorisatie
Knowledge transfer/sharing	Kennisverspreiding
Market opportunities	Kansen in de markt/industrie
Articles	Artikelen
Papers	Verslag
Patent (application)	Patent (aanvraag)
Final users	Eindgebruikers van kennis
Commercialisation (opportunities)	Commercialisatie (kansen)
Protection	Protectie
Market research	Verkenning van de markt
Job creation	Banencreatie
Knowledge dissemination	Kennis disseminatie

Source: Indicators selected by SEO (2021) based on Finne et al (2011)

Table A.1 The majority of reports, 91 per cent, contains at least one keyword

Project	Keywords
1	Spin-off, knowledge sharing, market research
2	Further research, spin-off
3	Spin-off
4	Further research
5	Publications
6	Knowledge sharing, conferences, articles, spin-offs, further research
7	Spin-off, job creation
8	Papers, publications
9	Knowledge dissemination, publication
10	Knowledge transfer
11	Publications
12	Publications, presentations, conference, papers, market research
13	Presentations, knowledge sharing
14	Presentations, publications, articles
15	Further research
16	Further research, publications, spin-offs
17	Further research, commercialisation
18	Knowledge dissemination
19	Commercialisation
20	Spin-off, publication, further research
21	Spin-off, further research, presentations, publications
22	Patent application, publication
23	Knowledge spread
24	Presentations, conferences, papers
25	Market research
26	Further research
27	Market research, presentations
28	Papers, presentations
29	Publications, knowledge sharing
30	Market research
31	Publications
32	Publications, thesis, conferences

33	Conferences, papers
34	Presentations, knowledge sharing
35	Presentations, publications, knowledge sharing
36	Publication, further research, presentations
37	Knowledge sharing publications, thesis
38	Papers, conferences, presentations
39	Conferences, presentations, publications
40	Spin-offs, publications
41	Conferences, presentations, publications
42	Spin-off
43	Presentations conferences, publications
44	Spin-offs, presentations, conferences
45	Conferences, market research, further research
46	Publications, conferences
47	Publications, , presentations spin-offs
48	Spin-offs, further research, conferences, publications
49	Further research
50	Spin-offs
51	Publications, thesis presentations
52	Presentations, conferences, publications

Appendix B Descriptive figures

Table B.1 Overview of survey results

Question	Yes	No	Not sure
Was valorisation part of the project plan?	76%	14%	-
Did you succeed in the valorisation mission?	47%	6%	47%
Was the type of collaboration beneficial for knowledge sharing purposes?	93%	7%	-
Did your project result in (scientific) publications?	93%	7%	-
Did RVO/NWO sufficiently stimulate to commercialise?	50%	21%	29%
Did your project result in any spin-off activities?	64%	29%	7%
Did your project result in further research?	74%	7%	19%
Will you apply for subsidy again?	72%	28%	-
Did you apply for patens during or shortly after the project?	27%	73%	-
Did you participate in presentations, workshops or conferences?	88%	12%	-

Source: SEO Amsterdam Economics (2021)

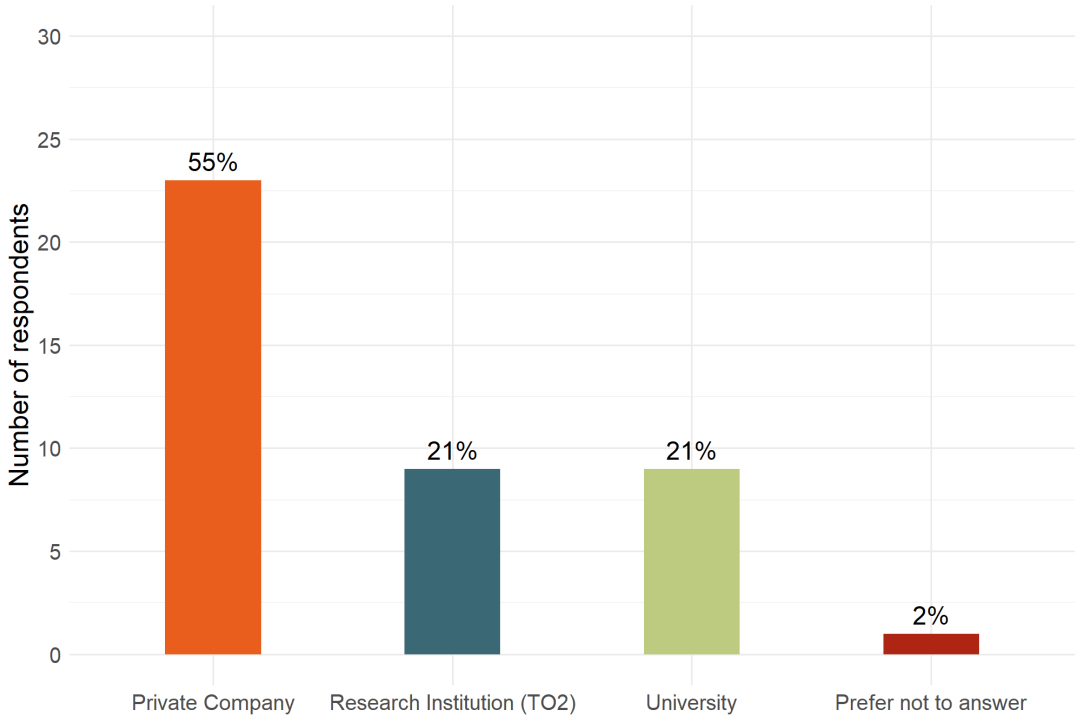
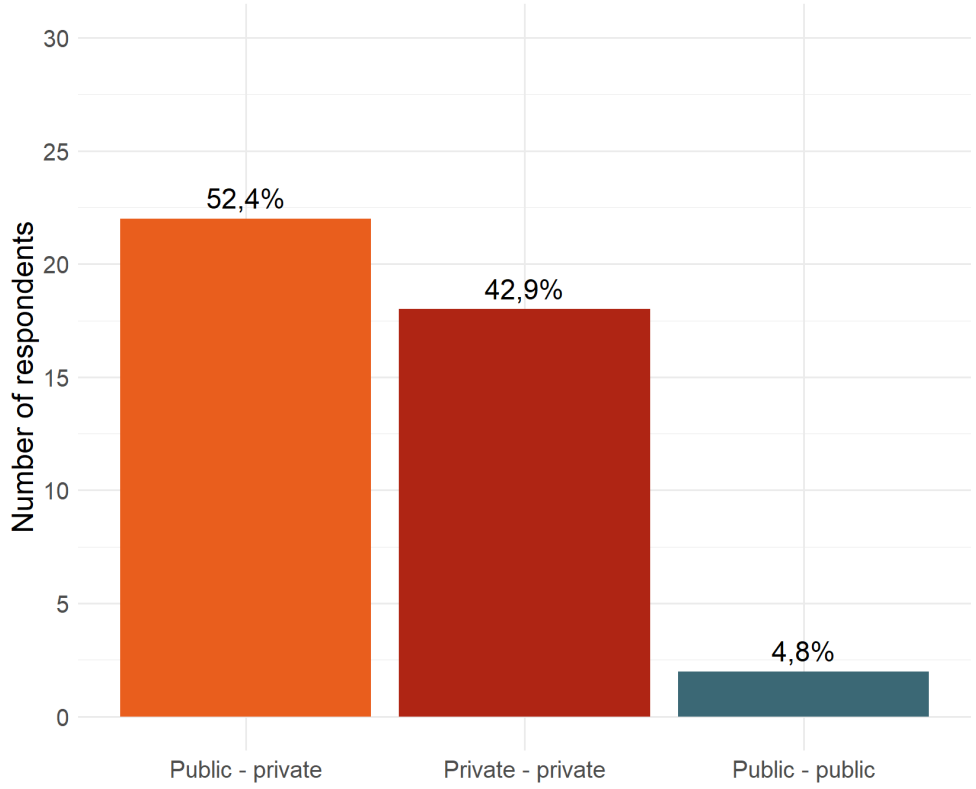


Figure B.1 Overview of the type of organisation the respondents represent (42 respondents)

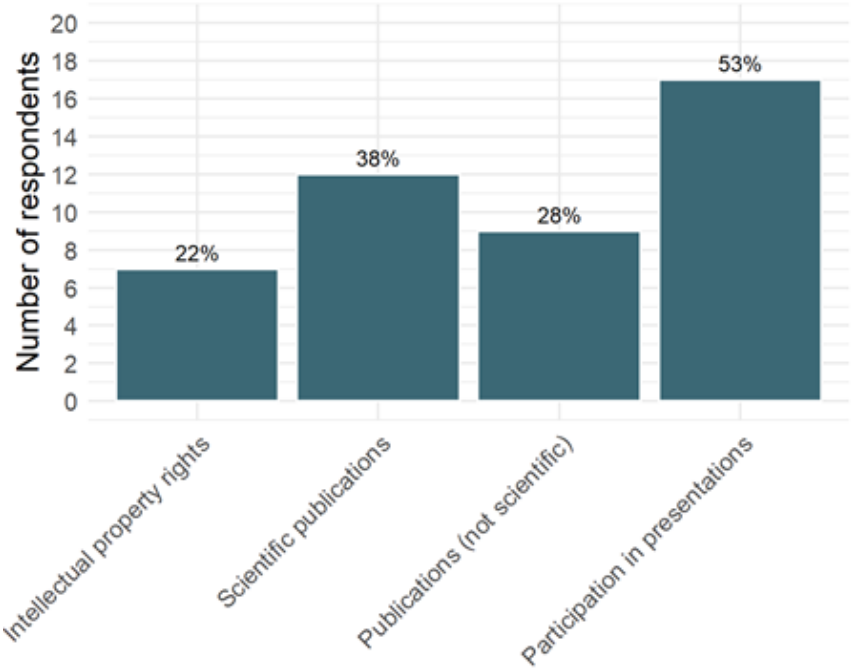
Source: SEO Amsterdam Economics (2021)

Figure B.2 Overview of the type of collaboration of the respondents' projects (42 respondents)



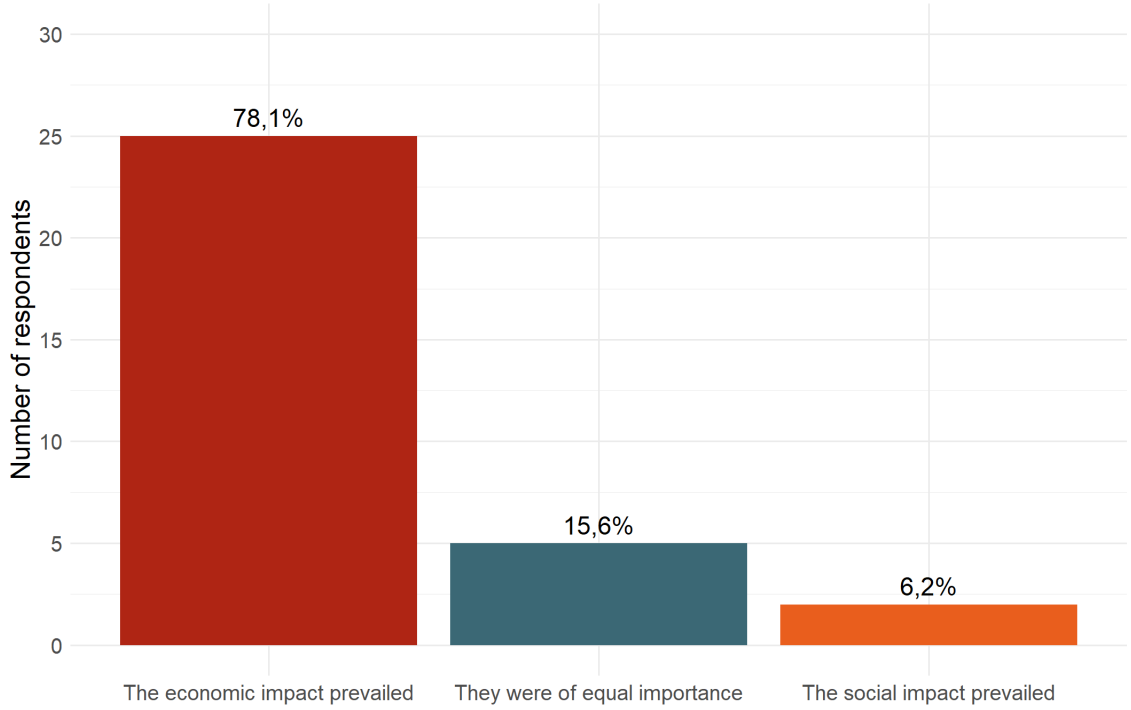
Source: SEO Amsterdam Economics (2021)

Figure B.3 Overview of the type of knowledge sharing activities that are specified in the project plan (42 respondents)



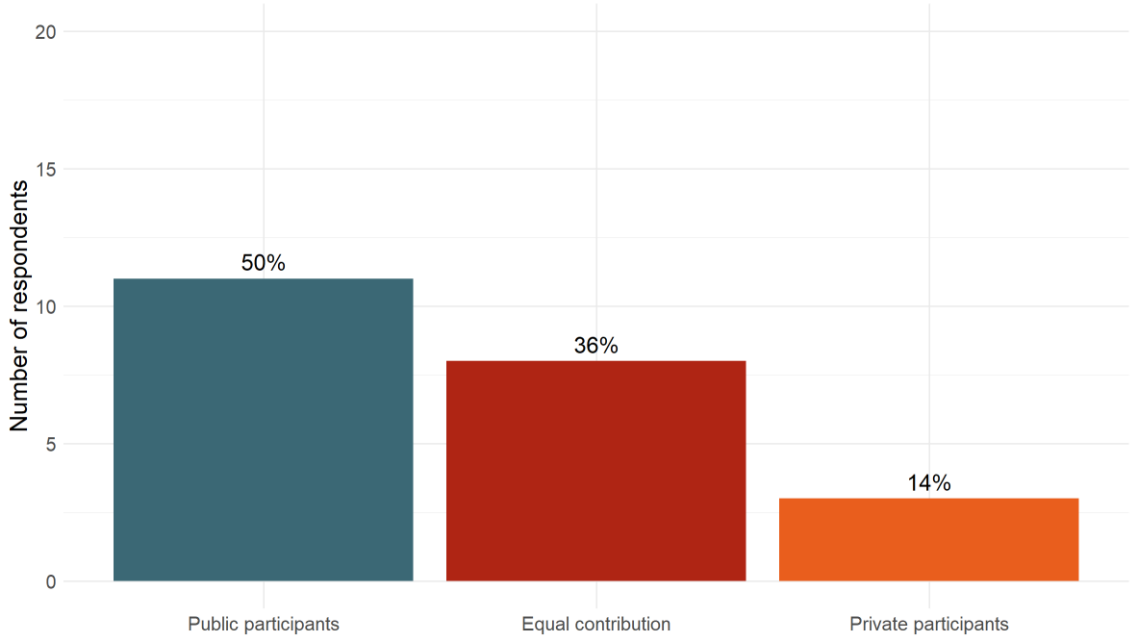
Source: SEO Amsterdam Economics (2021)

Figure B.4 Overview of the aim of the respondents' projects (32 respondents)



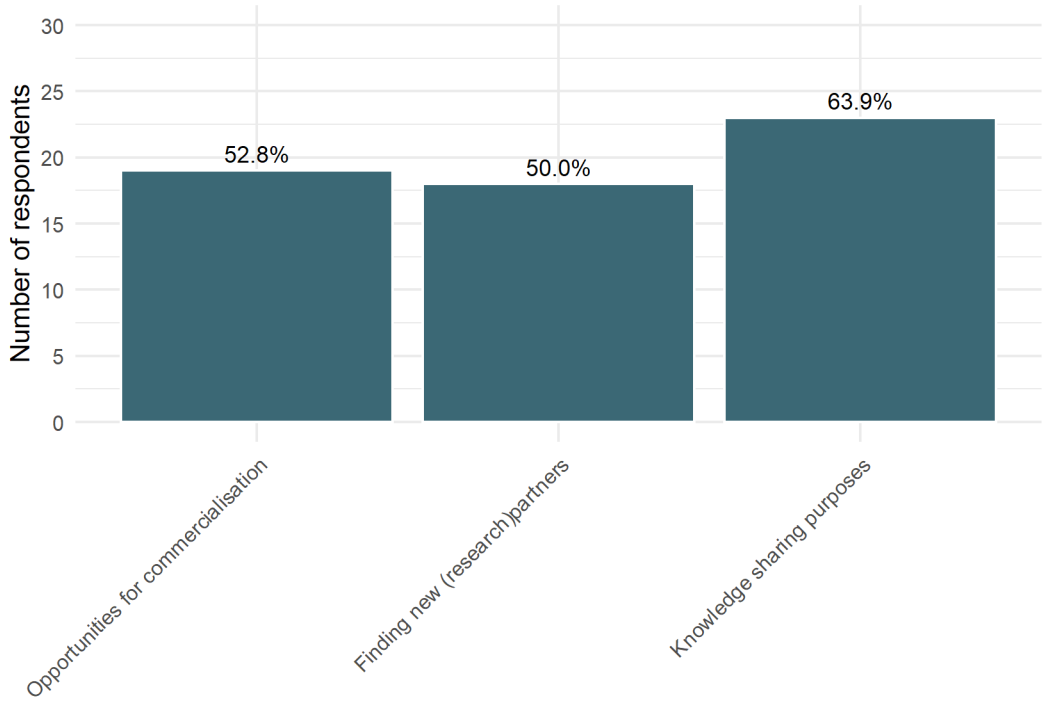
Source: SEO Amsterdam Economics (2021)

Figure B.5 Overview of which type of participant was mostly responsible for developing new knowledge according to the principal investigator (22 respondents)



Source: SEO Amsterdam Economics (2021)

Figure B.6 Overview of the incentives to join events, presentations and/or conferences of the principal investigators (32 respondents)



Source: SEO Amsterdam Economics (2021)

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