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The availability, utilization and effectiveness of innovation policy instruments within public procurement

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ABSTRACT (English)

Purpose: On average twelve percent of the GDP is spend in public procurement (OECD, 2017b, p.172). Due to the economic significance of public procurement, public procurement is frequently used to accomplish secondary policy objectives, such as innovation. Within the search for procuring innovation, demand-side instruments are often underrecognized. Through the development of a framework, and an instrument usage and effectiveness analysis, this thesis aims to provide knowledge about the availability, usage and effectiveness of demand-side public procurement innovation policy instruments.

Design: The framework of available innovative demand-side instruments within public procurement is based on existent literature, existent case-studies and government websites. The categorization of the framework is based on Vedung's sticks, carrots and sermons approach. The usage and effectiveness analysis are preformed using qualitative comparison analysis (QCA). The input is provided through a questionnaire filled out by 24 public procurements experts functioning as country representatives.

Findings: Demand-side innovation instruments range from regulative (i.e. restrictive laws and set targets), to materialistic (i.e. R&D funding), to knowledge transfer (i.e. websites and training). The full framework is provided in the study. Different combinations of instruments lead to different effectiveness levels. Generally speaking, knowledge transfer instruments and materialistic instruments are preferred over regulative instruments. Within materialistic instruments, one is advised to choose instruments within the category R&D funding, whereas government declarations are a safe choice for knowledge transfer instruments.

Value: The newly structured framework, based on the Vedung categorization, provides an overview of the availability of different innovation instruments that did not previously exist within the public procurement literature. Secondly, this research provides an overview of how often specific demand-side innovation instruments are available. Thirdly, this study minimizes the gap between potential and actual perceived benefits of demand-side innovation policy instruments within public procurement.

Keywords: public procurement; innovation; policy; instruments; demand; effectiveness; usage; framework; QCA

ABSTRACT (Nederlands)

Doel: Gemiddeld wordt twaalf procent van het bruto binnenlands product uitgegeven aan openbare aanbestedingen (OECD, 2017b, p.172). Vanwege de grote economische impact van deze aanbestedingen wordt publieke inkoop steeds vaker ingezet voor secundaire beleidsdoeleinden zoals het inkopen van innovatie. Uit de literatuur blijkt dat de instrumenten om innovatie te stimuleren aan de aanbodzijde veelal bekend zijn, daarentegen zijn de mogelijke innovatie instrumenten aan de vraagzijde onvoldoende bestudeerd en erkend. Middels de ontwikkeling van een raamwerk en analyse van het instrumentgebruik en de effectiviteit, tracht deze studie inzicht te verschaffen in de beschikbaarheid, het gebruik en de effectiviteit van instrumenten binnen het innovatiebeleid aan de vraagzijde van overheidsopdrachten.

Ontwerp: Het raamwerk van beschikbare innovatie instrumenten aan de vraagzijde van openbare aanbestedingen is gebaseerd op bestaande literatuur, casestudies en overheidspagina's van 23 verschillende landen. De categorisatie van het kader is gebaseerd op het model van Vedung, welke beleid categoriseert onder 'stok, wortel en preek', gebaseerd op de stok-wortel metafoor. De analyse voor gebruik en effectiviteit van de instrumenten is uitgevoerd middels een kwalitatieve vergelijking analyse (QCA). De data is verzameld uit een vragenlijst die verspreid is onder 24 experts in openbare aanbestedingen, welke functioneren als landvertegenwoordigers binnen dit onderzoek.

Bevindingen: Innovatie instrumenten aan de vraagzijde variëren van regulerend (bv. beperkende wetgeving of gestelde doelen), materialistische instrumenten (bv. R&D-financiering) tot kennisoverdracht instrumenten (bv. websites en training). Het volledige kader is weergegeven in de studie. Verschillende combinaties van instrumenten leiden tot verschillende levels van effectiviteit. Over het algemeen hebben materialistische- en kennisoverdracht-instrumenten de voorkeur boven regulerende instrumenten. Binnen de materialistische instrumenten wordt de subcategorie R&D-financiering boven andere subcategorieën geprefereerd. Binnen de categorie kennisoverdracht worden actieplannen van de overheid als een veilig instrument beschouwt om innovatie te bevorderen.

Waarde: Het nieuwe raamwerk, gebaseerd op de Vedung-categorisatie, biedt een categorisatie van de beschikbaarheid van innovatie-instrumenten aan de vraagzijde. Daarnaast geeft deze studie een indicatie van de frequentie van de beschikbaarheid van instrumenten ten

opzichte van de andere instrumenten. Ten slotte minimaliseert deze studie de kloof tussen de potentiële voordelen die bediscussieerd worden in de literatuur en de werkelijke voordelen volgens vak professionals.

MANAGEMENT SUMMARY

On average twelve percent of the GDP is spend in public procurement (OECD, 2017b, p.172). Due to the economic significance of public procurement, public procurement is frequently used to accomplish secondary policy objectives, such as innovation. Within the search for procuring innovation, demand-side instruments are often underrecognized. Demand-side instruments are instruments in which the government (buyer) ensures the procurement of innovation. Based on literature, case-studies and government websites the following framework was developed, that indicates the different types of demand-side innovation instruments that could be used to increase innovations through public procurement. Sermons refer to the instruments within the category of knowledge transfer, whereas sticks are regulative instruments and carrots are materialistic instruments. This framework can be used by practitioners to spot gaps and opportunities within the current available innovation instruments of a government or public organisation.
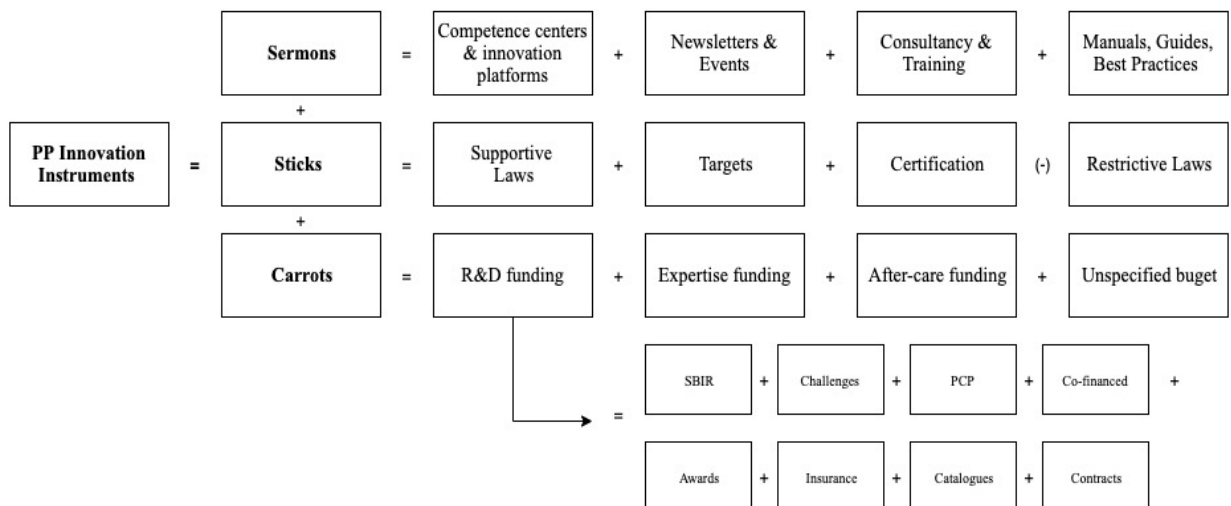
This framework was constructed based on the information (case-studies, literature, and government websites) of 23 countries. Comparing the instruments availability throughout the

23 countries provides an overview of which instruments are used where and how often. A frequency count indicates that instruments in the sermon category are available twice as often, compared to sticks and carrots. Additionally, the subcategories of restrictive laws, targets, certification, expertise funding, aftercare funding and non-specified government budgets are not frequently found (in less than 5 out of the 23 countries). R&D funding and guides on the other hand, are often available in countries (in at least 15 out of 23 countries).

Based on the framework, a questionnaire was developed, which formed the basis of the usage analysis of the instruments. The usage analysis is preformed using qualitative comparison analysis (QCA) where the data is provided through a questionnaire, filled out by 24 public procurements experts functioning as country representatives. The results include the combinations of instruments that are used by the most countries. For example, if materialistic instruments were used by countries to procure innovations, most countries used a combination of instruments within the categories of R&D funding, expertise funding, aftercare funding and unspecified budget funding. For R&D funding, however, no frequently occurrent pattern was found, as most countries use unique combinations of instruments.

$$(1)\ \textit{\textbf{general instruments usage pattern}}$$
$$= materialistic + regulative + informative\ instruments$$

$$(2)\ \textit{\textbf{regulative instruments usage pattern}}$$
$$= restrictive\ laws + supportive\ laws + targets + certification$$

$$(3)\ \textit{\textbf{materialistic instruments usage pattern}}$$
$$= R\&D\ funding + expertise\ funding + aftercare\ funding$$
$$+ unspecified\ budgets\ funding$$

$$(4)\ \textit{\textbf{R\&D funding instruments usage pattern}}$$
$$= unique\ combinations\ per\ country$$

$$(5)\ \textit{\textbf{informative instruments usage pattern}}$$
$$= competence\ centers\ \&\ information\ platforms$$
$$+ newsletters\ \&\ events + consultancy\ \&\ training + gguides\ \&\ manuals$$
$$+ overnment\ declarations\ \&\ action\ plans$$

Additionally, the usage analysis indicated discrepancies that managers should be aware of. First of all, the standard deviation of the usage variables was on average higher compared to the
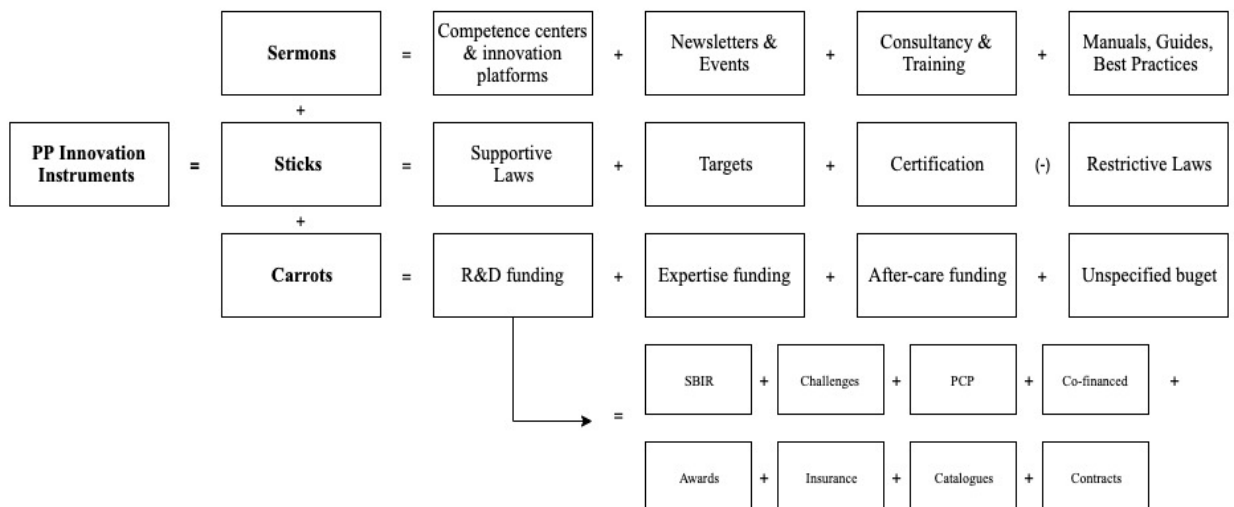
standard deviation of effectiveness variables. This indicates that respondents are more unanimous about which instruments are effective, compared to which instruments are used. Consequently, one should focus on the instruments that are perceived as more effective instead of more used (i.e. one should be aware that there is a difference). On a similar note, the means of the effectiveness of instruments is also higher compared to the means of the usage of instruments. This indicates that there is still an opportunity for management to increase the usage towards the effectiveness levels. Lastly, there is a discrepancy between the indicated usage in the first and second questionnaire. Whereas the first questionnaire was solely filled in by highly ranked procurement experts, the second questionnaire was distributed irrespectively of the hierarchy. This indicates that there is discrepancy between the usage on top level and on second level. This calls for an increase in awareness of innovation instruments in lower parts of the organizational hierarchy.

The effectiveness analysis was performed in a similar manner as the usage analysis. The analysis led to combinations of instruments that are perceived as most effective to increase the effectiveness of procurement of innovations, as well as instruments that are perceived as more effective compared to other instruments. The following blueprint indicates a simplified overview of the most effective instruments to increase procurement of innovations. First of all, materialistic (carrots) and knowledge transfer (sermons) instruments are preferred over the regulative instruments (sticks). Secondly, within the carrot categorization, R&D funding is preferred over the other sub-categories to achieve the highest effectiveness. Nevertheless, expertise funding and after care funding are favourable complements to R&D funding. When implementing the sticks categorization, supportive laws are preferable. Within sermons, many combinations can lead to an effective knowledge transfer, however, the presence of government declarations is the only categorization that always leads to high effectiveness. Lastly, some instruments are perceived as significantly more effective compared to others. It is advised to choose co-funding over small business innovation research (SBIR) or pre-commercial procurement, and co-funding, awards, challenges, and contracts over unsolicited proposals. Similarly, supportive laws and targets should be chosen before choosing for restrictive regulation.
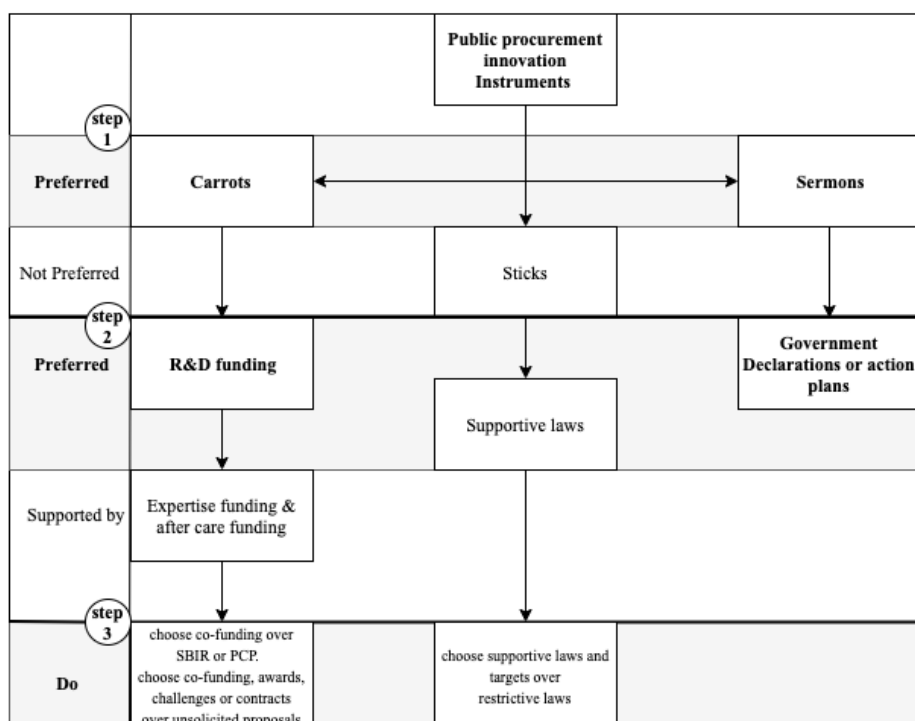
MANAGEMENT SUMMARY (Nederlands)

Gemiddeld wordt twaalf procent van het bruto binnenlands product uitgegeven aan openbare aanbestedingen (OECD, 2017b, p.172). Vanwege de grote economische impact van deze aanbestedingen wordt publieke inkoop steeds vaker ingezet voor secundaire beleidsdoeleinden zoals het inkopen van innovatie. Uit de literatuur blijkt dat de instrumenten om innovatie te stimuleren aan de aanbodzijde veelal bekend zijn, daarentegen zijn de mogelijke innovatie instrumenten aan de vraagzijde onvoldoende bestudeerd en erkend. Instrumenten aan de vraagzijde zijn instrumenten waarbij de overheid (als koper) de vraag voor de inkoop van innovatie delegeert (i.p.v. de aanbieder). Op basis van literatuur, casestudies en overheidswebsites is het volgende raamwerk ontwikkeld, dat de verschillende categorieën van innovatie instrumenten aan de vraagzijde weergeeft, die kunnen worden gebruikt om innovaties doormiddel van openbare aanbestedingen te vergroten. 'Sermon' verwijst naar de instrumenten die binnen de categorie kennisoverdracht vallen, 'sticks' zijn regulatieve instrumenten en 'carrots' zijn materialistische instrumenten. Dit raamwerk kan door vak professionals worden gebruikt om de huidige beschikbare innovatie instrumenten binnen de organisatie te vergelijken met het raamwerk, door zo nieuwe mogelijkheden te ontdekken.

PP Innovation Instruments =

Sermons = Competence centers & innovation platforms + Newsletters & Events + Consultancy & Training + Manuals, Guides, Best Practices

+

Sticks = Supportive Laws + Targets + Certification (-) Restrictive Laws

+

Carrots = R&D funding + Expertise funding + After-care funding + Unspecified buget

R&D funding = SBIR + Challenges + PCP + Co-financed +

Awards + Insurance + Catalogues + Contracts

Dit raamwerk is opgebouwd uit literatuur, casestudies en overheidswebsites van 23 landen. Het vergelijken van de beschikbaarheid van de instrumenten in de 23 landen geeft een overzicht van welke instrumenten waar en hoe vaak gebruikt worden. Een frequentie-telling geeft aan dat 'sermons' twee keer zo vaak beschikbaar zijn in vergelijking met 'sticks' en 'carrots'. Daarnaast komen de volgende subcategorieën weinig voor (in minder dan 5 van de 23 landen): beperkende wetten, targets, certificatie, expertise financiering, financiering van nazorg en de niet gespecificeerde overheidsbudgetten. R&D-financiering en handboeken zijn daarentegen vaak beschikbaar (in meer dan 15 van de 23 landen).

Op basis van het raamwerk is een vragenlijst ontwikkeld die de basis vormt voor de analyse over het gebruik van de innovatie instrumenten. De analyse voor het gebruik van de instrumenten is uitgevoerd middels een kwalitatieve vergelijkingsanalyse (QCA). De data is verzameld uit een vragenlijst die verspreid is onder 24 experts in openbare aanbestedingen, welke functioneren als landvertegenwoordigers binnen dit onderzoek. De resultaten omvatten de combinaties van instrumenten die door de meeste landen worden gebruikt. Als landen bijvoorbeeld materialistisch instrumenten gebruiken om innovaties aan te schaffen, gebruikten de meeste landen een combinatie van R&D-financiering instrumenten, expertise financieringsinstrumenten, nazorg financiering en niet gespecificeerde budgetfinanciering. Binnen de R&D-financiering, daarentegen, wordt geen frequent patroon aan combinaties gevonden. De meeste landen gebruikten unieke combinaties van verscheidene instrumenten.

$$(\mathbf{1})\ \textit{algemene gebruikerspatroon van innovatie instrumenten}$$
$$= materialistisch + regulatief + informatief$$

$$(\mathbf{2})\ \textit{gebruikerspatroon van regulatieve instrumenten}$$
$$= beperkende\ wetgeving + supportende\ wetgeving + targets$$
$$+ certificatie$$

$$(\mathbf{3})\textit{gebruikerspatroon van materialistische instrumenten}$$
$$= R\&D\ financiering + expertise\ financiering + nazorg\ financiering$$
$$+ niet\ gespecificeerde\ overheidsbugetten$$

$$(\mathbf{4})\ \textit{gebruikerspatroon van R\&D financiering instrumenten}$$
$$= per\ land\ unieke\ combinaties\ van\ verschillende\ instrumenten$$

$$(\mathbf{5})\ \textit{gebruikerspatroon van informatieve instrumenten}$$
$$= competence\ centers\ \&\ informatie\ platforms$$
$$+ nieuwsbrieven\ \&\ evenementen + consultancy\ \&\ training$$
$$+ gidsen\ \&\ handboeken + actieplannen\ van\ de\ overheid$$

Naast de gebruikerspatronen van de innovatie instrumenten, gaf de analyse nog drie inzichten. Allereerst: de standaarddeviatie van de gebruiksvariabelen lag gemiddeld hoger in vergelijking met de standaarddeviatie van de effectiviteitsvariabelen. Dit geeft aan dat de respondenten het meer eens zijn over welke instrumenten effectief zijn dan dat ze hetzelfde gebruikerspatroon hebben. Bijgevolg moet men zich concentreren op de instrumenten die als effectief(er) worden beschouwd in plaats van de instrumenten die meer gebruikt worden (men moet zich ervan bewust zijn dat er een verschil is). Evenzo is het gemiddelde van de effectiviteit van de instrumenten ook hoger in vergelijking met het gemiddelde van het gebruik van het instrument. Dit geeft aan dat het management de mogelijkheid heeft om het gebruik van de instrumenten te verhogen naar de bijbehorende effectiviteitslevels. Ten slotte is er een discrepantie tussen het aangegeven gebruik van de instrumenten in de eerste en tweede vragenlijst. Waar de eerste vragenlijst uitsluitend werd ingevuld door hooggeplaatste inkoopdeskundigen werd de tweede vragenlijst ook onder lagere ranken verspreid. Het verschil in aangegeven gebruik geeft aan dat het inkoopmanagementteam tijd en energie moet steken in het toenemen van de bewustwordingen van het bestaan en gebruik van de innovatie instrumenten in de lagere delen van de organisatie hiërarchie.

De analyse voor effectiviteit van de instrumenten is uitgevoerd middels dezelfde methode als de gebruiksanalyse. De analyse leidde tot combinaties van instrumenten die als het meest effectief worden beschouwd, evenals instrumenten die als effectiever worden beschouwd in vergelijking tot andere instrumenten. De volgende blauwdruk geeft een vereenvoudigd overzicht weer van de meest effectieve instrumenten. Allereerst hebben materialistische (carrots) en kennisoverdracht (sermons) instrumenten de voorkeur boven regulerende instrumenten (sticks). Ten tweede heeft R&D-financiering binnen de carrots-categorie de voorkeur boven de andere subcategorieën. Financiering voor expertise en nazorg zijn echter een goede aanvulling op R&D-financiering. Wanneer instrumenten van de stick-categorisatie worden geïmplementeerd, hebben ondersteunende wetten de voorkeur. Binnen sermons, kunnen veel verschillende combinaties leiden tot effectieve kennisoverdracht, maar de aanwezigheid van overheidsverklaringen en actieplannen is de enige subcategorie die altijd leidt tot een hoge effectiviteit. Ten slotte worden sommige instrumenten als aanzienlijk effectiever beschouwd dan anderen. Zo wordt geadviseerd om cofinanciering te verkiezen boven 'Small Business Innovation Research' (SBIR) of 'Pre-commercial Procurement' (PCP). Awards, challenges, en contracten worden geprefereerd boven ongevraagde voorstellen (unsolicited proposals). Evenzo moeten ondersteunende wetten en doelen worden verkozen boven de beperkende regelgeving.
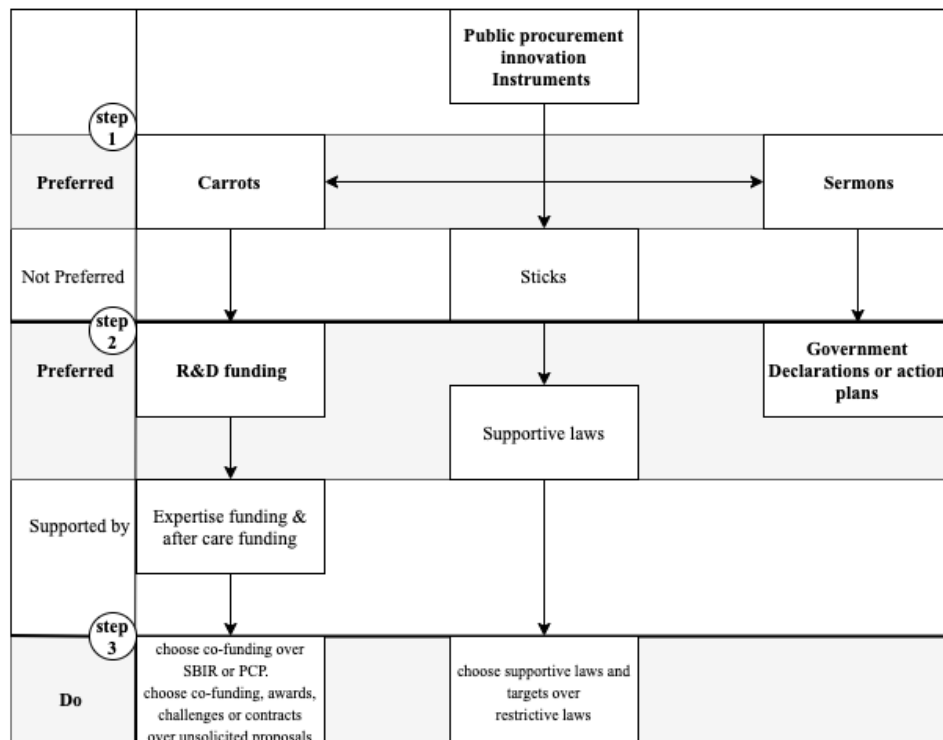
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LIST OF ABBREVIATIONS

AgID	*Digital Italy Agency*
ANI	*Agency National Innovation*
ANOVA	*Analysis of Variance*
BRII	*Business Research and Innovation Initiative*
CAD	*Canadian Dollars*
CDP	*Continuous Professional Development*
CDTI	*Centre for the development of industrial technology*
CEO, CFO, CPO	*Chief Executive Officer, Chief Financial Officer, Chief Procurement Officer*
CONSIP	*Concessionaria Servizi Informativi Pubblici*
EAFIP	*European Assistance For Innovation Procurement*
EAS	*Enterprise Estonia*
EC	*European Commission*
ERDF	*European Regional Development Fund*
ESIF	*European Structural Investment Fund*
FAQ	*Frequently Asked Questions*
GDP	*Gross Domestic Product*
GSRT	*General Secretariat for Research and Technology*
ION	*Innovationsfördernde Öffentliche Beschaffung*
ISO	*International Organization for Standardization*
KOINNO	*Kompetenzzentrum innovative Beschaffung*
KOSBIR	*Korean Small Business Innovation Research Program*
MEAT	*Most Economically Advantageous Tender*
NHS	*National Health Service*
OECD	*Organisation for Economic Co-operation and Development*
PCP	*Pre-Commercial Procurement*
PIANOo	*Professioneel en Innovatief Aanbesteden, Netwerk voor Overheidsopdrachtgevers*
PIO	*Programma Innovatieve Overheidsopdrachten*
PP	*Public Procurement*
PPI	*Procurement of Innovative Solutions*
PPPI service centre	*Public Procurement of Innovations service centre*
PTI	*Procurement Transformation Institute*
Q&A	*Question and Answer*
QCA	*Qualitative Comparison Analysis*
R&D	*Research & Development*
SBIR	*Small Business Innovation Research*
SBRI	*Small Business Research Initiative*
SME	*Small and Medium Enterprises*
SD	*Standard deviation*
TechFar	*Technical Federal Acquisition Regulation*
UNDP	*United Nations Development Program*
WTO	*World Trade Organization*
ZIM	*Central Innovation Program*

1. Introduction: Innovation within the public procurement context

1.1 Public procurement as a new source of innovation

"Carrying out innovations is the only function which is fundamental in history" (Schumpeter, 1939, p.102). Innovations defined as new combinations of knowledge and resources, which are subjected to commercial practice (Schumpeter, 1934, p. 65), are according to Schumpeter at the center of the economic evolution, where *"creative destruction"* is the *"essence of capitalism"* (Schumpeter, 1942, p.104). Innovation is often linked to the vitality of firms in terms of a sustainable advantage. Nevertheless, innovation typically creates benefits for everyone while incurring all the costs oneself, also known as positive externalities in classical economic theory (Jaffe, Newel & Stavins, 2004, p.84). Consequently, the opportunity to foster innovation might lay with the government: to create an environment supportive for innovations, e.g. through public procurement.

The governmental purchase of goods and services is called public procurement. On average twelve percent of Gross Domestic Product (GDP) is spent on public procurement, whereas 29 percent of total government expenditures is allocated to public procurement (OECD, 2017b, p.172). In the Netherlands, for example, public procurement accounts for 20.2 percent of GDP, which equals almost half of government spending (OECD, 2017b, p.172). Twenty percent of the Dutch GDP translates to over 147 billion euros spend on public procurement in 2017, indicating the economic significance of public procurement within a country (Statistica, 2018). This economic significance consequently emphasizes the strategic potential within public procurement.

Due to its large economic volume, public procurement is frequently used to accomplish secondary policy objectives (OECD, 2017b, p.174). These secondary policy objectives can relate to either environmental, economic and/or social challenges. Examples include 'green public procurement', the 'support of small and medium enterprises (SMEs)', but also 'innovative goods and services' (Magina, 2019, p.4). In the 2018 public procurement survey of OECD, hundred percent of the OECD countries have developed a green public procurement strategy or policy, 93 percent have developed a policy or strategy for the support of SMEs, and 83 percent have developed a strategy or policy for innovative goods and services (Magina, 2019, p.4). Underlining the usage of public procurement as a strategic policy tool for innovation among others.

1

1.2 Research Outline: The need for identification and measurement of demand-side innovation policy instruments within public procurement

Whilst there are noticeable opportunities for innovation through public procurement, Edler and Georghiou (2007, p. 961) argue for "the *need to take demand, more concretely public demand, more into the focus of innovation policy making*". Within innovation, demand-side innovations are often underrecognized, as innovation typically relies on the supply of products, services and ideas (Edler & Georghiou, 2007, p.949). Similarly, public procurement of innovation can be either demand or supply driven, depending on if the initiative is taken by the buyer (government) or supplier. This study focuses on the demand side of innovations, in which the government takes the initiative. Elder and Georghiou (2007, p.952), define demand-side policies as the following: "*all public measures to induce innovations and/or speed up diffusion of innovations through increasing the demand for innovations, defining new functional requirement for products and services or better articulating demand*".

Although Edler and Georghiou (2007) urge for more focus on the demand-side of innovation policy, some research already has been done (see Aschhoff & Sofka (2009), Edler & Georghiou (2007), Edquist & Zabala-Iturriagagoitia (2012), Hommen & Rolfstam (2008), Mowery & Rosenberg (1979) and Rothwell (1984)). Additionally, domestic case-studies on demand-side policies are available (see Audretsch (2003), Choi, Lee, & Lee (2014), Li (2011), Rammer (2011) and Zaparucha & Muths (2011)). However, studies to date specifically focused on identifying and classifying public procurement innovation policy instruments into a framework. Additionally, the availability of such demand-side policies within countries has not been studied before. Research as such could include for example, how many countries use subsidies to increase the demand for innovative procurement or how often are websites used by countries to inform organizations about public procurement innovation opportunities. Therefore, a research gap exists in the availability of public procurement innovation policy instruments. To fill this gap, the following research question is asked:

RQ1: Which innovation policy instruments are available within public procurement institutions?

Whereas the potential of strategic procurement for innovation objectives is often recognized, as proven by the developed policies and strategies—as 83 percent of the OECD countries have developed a strategy for innovative goods or services—evidence of the benefits

is not equally visible (OECD, 2017a, p.42). This is –at least partially—a result of an uneven follow-up and measurement system between different secondary policy objectives. Whereas 74 percent of the OECD countries have a measurement system for 'green public procurement' and 68 percent have a measurement system for the 'support of small and medium enterprises (SMEs)', merely 32 percent of the countries have such a system for 'innovative goods and services' (Magina, 2019, p.5-6). Hence, the lack of a measurement system indicates a missed opportunity in terms of evidence of the benefits and effectiveness of such innovation policies.

In summary, due to the economic significance of public procurement, public procurement is increasingly being used for secondary policy objectives (OECD, 2017b, p.174). One of these secondary policy objectives is innovation. Hence, Schumpeter's notion that *"Carrying out innovations is the only function which is fundamental in history"* (Schumpeter, 1939, p.102) is –at least partially—recognized by governments in terms of applying innovation policies and strategies. However, the evidence of the benefits and effectiveness of such policies and strategies is missing (OECD, 2017a, p.42). Accordingly, this thesis aims to reduce this discrepancy by sketching an overview of the utilization and effectiveness of innovation policies within public procurement by asking the following research questions:

RQ2: Do patterns in public procurement innovation policy instruments prevail in terms of usage?

RQ3: Do patterns in public procurement innovation policy instruments prevail in terms of effectiveness?

To answer the first research question, the current literature and government websites are reviewed to develop a framework of available innovation instruments within public procurement. This framework will then be validated by public procurement experts of fifteen countries during an international research study, using case-studies in which the experts indicate the available instruments within their country. Afterwards, to answer the second and third research question, a qualitative comparison analysis (QCA) will be performed based on the developed framework. The analysis is based on a questionnaire where public procurement experts (such as government chief procurement officers) are functioning as country representatives of 24 countries and are asked to indicate the perceived usage and effectiveness of innovation policy instruments within their government, in relation to public procurement. Hence, the perceived usage and effectiveness of innovation instruments are measured by the

opinions of the public procurement experts. Afterwards, a more widely distributed questionnaire, conducted by the international research study committee, will serve as a validity analysis on the usage and effectiveness results.

1.3 Thesis outline: Explanation of Each Chapter

Figure 1 visualizes the research approach this study. First, the theoretical background of procurement of innovations is discussed, functioning as a theoretical clarification before the development of the framework. Secondly, in the following four chapters the existing literature will be reviewed, and an availability framework will be developed, as part of the first step. Within this first step which starts at chapter three, chapter three serves as an introduction, chapter four indicates the design of the framework, chapter five provides the results of the literature review, whereas chapter six serves as a discussion and cross-analysis. Chapter seven validates the developed framework (i.e. step two). From chapter eight till ten, step three will be conducted, including an introduction, the methodology and the results of the usage and effectiveness analysis, using qualitative comparison analysis. The last step includes the validation of the usage and effectiveness analysis. For this step a different questionnaire will be used, which will be analysed using different non-parametric tests and descriptive statistics. Similar to the previous steps, this step also consists of three chapters: the introduction, the methodology and the results. The last two chapters will conclude this research with the discussion and conclusion. In the discussion, the managerial implication and the contribution to literature are explained. In the conclusion, the limitations and opportunities for future research are discussed.
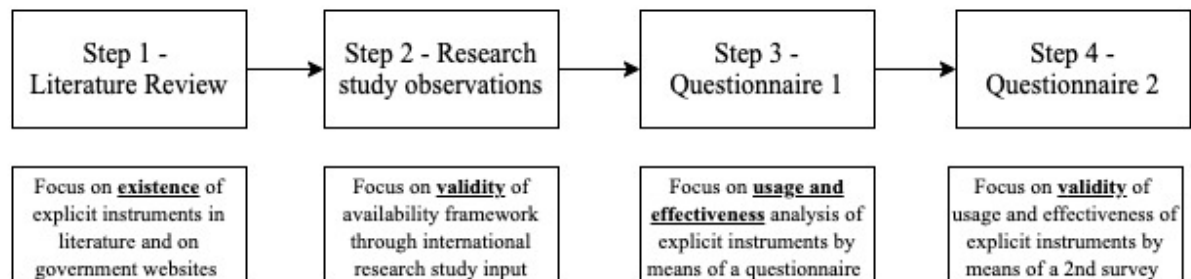
Figure 1: the research approach

2. Conceptual background: Defining and conceptualizing public procurement of innovations

2.1 Definitions: Procurement of innovations, innovation, innovation policy and innovation instruments

First, a clarification should be made between 'innovations in procurement' and 'procurement of innovations'. This thesis concerns itself with the latter; procurement of innovations. That is, the process of buying of innovative products and services by the government (Hommen and Rolfstam, 2008, p.21). Innovations in procurement, i.e. innovations within the process of public procurement (Hommen and Rolfstam, 2008, p.21), are not within the scope of this paper.

The notion of innovation is close to a century old, were in 1934, Schumpeter defined it as new combinations of knowledge and resources, which are subjected to commercial practice (p. 65). A newer definition however, is "*new creations of economic and societal significance carried out by firms*" (Edquist & Zabala-Iturriagagoitia, 2012, p.1758; Borrás and Edquist, 2013, p.1513). Over the century, different definitions of innovation evolved, encompassing many perspectives, ranging from very broad to very narrow. Consequently, this wide range of perspectives is reflected in the wide range of definitions and interpretations of an innovation policy. Increasing the difficulty of a definition for innovation policy is the fact that innovation policy is a relatively new term that gained popularity around the millennium (Edler and Fagerberg, 2017, p.3). Innovation policy is in this research defined as "*all combined actions that are undertaken by public organizations that influence innovation processes*" (Borrás and Edquist, 2013, p.1513). Closely related to policies are policy instruments, which are described as the techniques developed in order to achieve policy ideas (Edler and Fagerberg 2017, p.11).

2.2 Sticks, carrots and sermon analogy as classification for innovation policy instruments within public procurement

Policy instruments, described as the techniques developed in order to achieve policy ideas (Edler and Fagerberg 2017, p.11) have a range of variations. Examples of such instruments—among others—include informative websites, subsidies and laws. To provide an overview of such instruments, a classification is desired. A commonly used classification of Public Policy Instruments is the 'sticks, carrots and sermons' approach by Vedung (Bemelmans-Videc, Rist & Vedung, 2011, p.1). This categorization is based on the carrot and stick metaphor, referring to the reward and punishment options to induce desired behavior. One might use the stick as

punishment to induce innovation, whereas a carrot represents the reward for inducing innovation, and the sermon represents the necessary knowledge to induce innovation.

Sticks are classed as regulative instruments, whereas carrots represent the economic means, and sermons the informative measures. The first category, regulations, entails formal rules and directives that are enforced by the government. The focal point of regulations being on the authoritative relationship between regulator (government) and the subjects regulated (Bemelmans-Videc, Rist & Vedung, 2003, p.10). Carrots, the second category, revolves around materialistic resources (e.g. a subsidy or tax reduction). The sermons category refers to the transfer of knowledge, such as providing training and online information platforms (Bemelmans-Videc, Rist & Vedung, 2011, p.11).

2.3 Development stages of Public Procurement as constrain for procurement of innovation

The public procurement strategy of a country can be classified in terms of stage of development, where the stage of development is dependent on the country. Differences in development impact the initial focus on secondary policy objectives such as innovation. Telgen, Harland and Knight (2007, p.20-22) developed a seven-stage framework on public procurement development, ranging from '*sourcing and delivering goods and services'* (stage 1) to '*deliverer of broader government objectives'* (stage 7). Table 1 displays the seven stages. In the first four stages, the focus lies solely on procurement of goods and services, disregarding the strategic usage of public procurement. Meaning that, from stage five onwards, the focus shifts from reactive to proactive, with contributed procured value as the main objective. From stage five onwards, strategic potential of public procurement is recognized. From stage six onwards, the focus shifts towards external, with a specific focus on policy objectives such as the stimulation of innovation. In the seventh stage, public procurement leads the social change, taking full responsibility for delivering a policy (Telgen, Harland & Knight, 2007, p.20-22). Hence, innovation through public procurement will be an activity reserved for countries and institutions that are at least within development stage five, as before stage five is strictly functional—i.e. non-strategic. Even though, in reality, stages are not always mutually exclusive (e.g. certain local municipalities, government institutions or projects are within a higher stage compared to the foundation of the country), it is an important notion that not all countries are in a similar

development stage and hence do not have a—similar—focus on public procurement of innovation. Consequently, not all countries will be represented and focused on equally in the public procurement innovation policy instrument framework.

Development stages in Public Procurement
1. Sourcing and delivering goods and services
2. Compliance with legislation/regulation
3. Efficient use of public funds
4. Accountability
5. Value for money
6. Supporter of broader government policy objectives
7. Deliverer of broader government objectives

Table 1: development stages in public procurement (adapted from Telgen, Harland & Knight, 2007, p.20-22).

3. Step 1 – Introduction: Literature study on existence of public procurement innovation policy instruments framework

A research gap exists in the availability of public procurement innovation policy instruments. To fill this gap, the following research question is asked:

RQ1: *Which innovation policy instruments are available within public procurement institutions?*

This question can be answered trough the development of a framework that includes the available innovation policy instruments in public procurement, which will be the first step of this study (figure 2). The framework will be presented using the policy categorization of Vedung (i.e. the stick, carrot, sermon approach). First, the methodology of this framework is explained. Secondly, the three categories—sticks, carrots and sermons—are presented in detail. Lastly, the discussion of the framework, in terms of patterns of existence is provided.
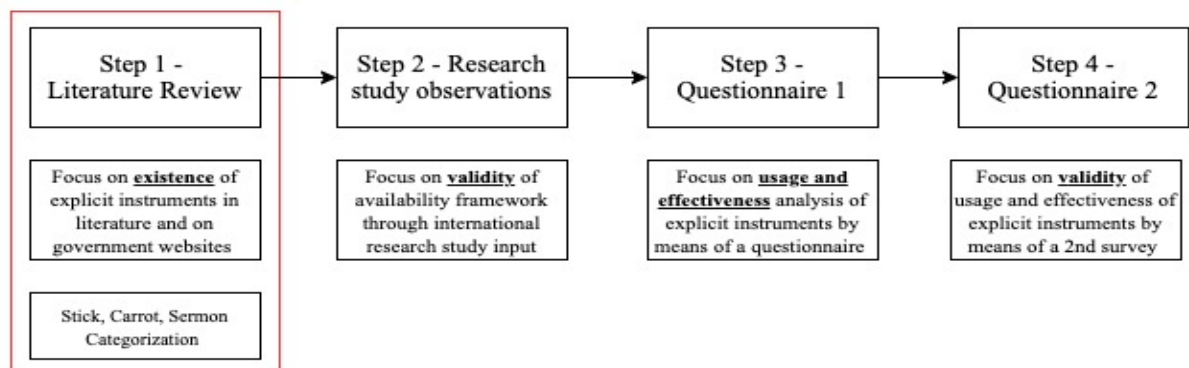
Figure 2: the research approach

4. Design: Developing a demand-side public procurement innovation policy instruments framework

4.1 Data collection: Evidence from scientific literature and government websites

The framework of public procurement innovation policy instruments is based on scientific literature and government websites. The initial search for scientific literature was based on search terms such as 'public procurement', 'innovation', 'instruments' and 'policy'. It became evident that while innovation opportunities through public procurement were largely empirically studied, the availability of public procurement innovation policy instruments are understudied empirically. Instruments that were found, were found in the case-studies of scientific literature. The second row of table 2 provides an overview of example studies found in relation to this demand-side public procurement innovation theory, whereas the third row indicates literature that includes case-studies on demand-side policies and instruments within public procurement of innovation. Hence, in addition to the case-studies, the instrument availability framework is extended with non-scientific literature, in the form of governmental websites. The initial search terms include the name of the 23 sampled countries, 'procurement', 'innovation', 'policy', and 'instruments'. Later on, other search terms emerged such as 'financial', 'economic', 'competence center', 'information', 'regulation', 'unsolicited proposals', 'government declaration', 'innovation action plan' and 'laws'.

Theme	Preeminent Scientific Articles
Innovation through public procurement	Aschhoff & Sofka (2009), Edler & Fagerberg (2017), Edler & Georghiou (2007), Edler et al (2005), Edquist & Zabala-Iturriagagoitia (2012), Georghiou et al (2014), Hommen & Rolfstam (2008), Mowery & Rosenberg (1979), Rothwell and Zegveld (1981) And Rothwell (1984) *(wider body of literature available)*
Public Procurement innovation policy instruments (i.e. case studies)	Audretsch (2003), Block (2008), Choi, Lee & Lee (2014), Edler et al (2005), Georghiou et al (2014), Lee & Jo (2018), Li (2011), Rammer (2011), Yeow & Edler (2012) and Zaparucha & Munths (2011) *(Extended with non-scientific literature)*

Table 2: scientific literature overview

4.2 Focus group: 23 countries selected for framework development

The seven stages by Telgen, Harland and Knight (2007) indicated the different phases of public procurement development, including its consequences for secondary policy objectives such as innovation. As a consequence, the focus group of this research is on developed countries,

who are believed to engage in activities of stage five and higher in the public procurement development framework (Telgen, Harland & Knight, 2007, p.20-22). This means that countries who solely focus on sourcing and delivering goods and services (stage 1); compliance with regulation (stage 2); efficient use of public funds (stage 3) and accountability (stage 4) are not included in the framework, as the focus of these governments does not lie with secondary policy objectives such as innovation. It is expected that countries from stage five onwards do—at least partially—focus on procurement of innovation, hence the focus of this research is on those countries. Based on the researcher's interpretation on the supposed development stage of the country, the following 23 countries were selected (table 3).

1. Australia	2. Austria	3. Belgium	4. Canada
5. China	6. Denmark	7. Estonia	8. Finland
9. France	10. Germany	11. Greece	12. Ireland
13. Italy	14. Korea	15. Lithuania	16. Netherlands
17. New Zealand	18. Portugal	19. Russia	20. Spain
21. Sweden	22. UK	23. US	

Table 3: countries selected for the literature review

4.3 From data to framework development: Constant comparison analysis and triangulation to categorize data into a developed framework

After the literature search, instruments were categorized according to the 'carrots, sticks and sermons' approach. This categorization was done based on the deductive (i.e. categories are identified beforehand) coding (i.e. constant comparison analysis) of the researcher (Leech & Onwuegbuzie, 2007, p.565). To ensure validity, alongside the researcher, one other researcher independently categorized the instruments into the carrots, sticks, and sermons categories (Burnhard, 1991, p.462). Comparing the deductive coding of the two researchers, no adjustments had to be made since the instruments were categorized identically by both researchers. Afterwards, a similar process was executed for defining the subcategories within the three categories. However, this time an inductive constant comparison analysis was done (i.e. sub-categories are not identified beforehand) (Leech & Onwuegbuzie, 2007, p.565). Afterwards, triangulation was performed by a second researcher using deductive coding. Based on the deductive coding no adjustments had to be made since the instruments were categorized identically by both researchers. After the constant comparison analysis and triangulation, sticks, for example, had four subcategories. These subcategories include law restrictive, law

supportive, target, and certification. After coding the initial framework was built which will be discussed later on.

4.4 From framework development to cross-comparison analysis: Occurrences of sticks, carrots and sermons categories provide patterns in terms of instrument availability.

Based on the initial framework, the first analysis was done. The first analysis focuses on the availability of a certain instrument within the 23 countries. Listwise, for each country it is investigated (using literature and government websites) if they have an instrument within each of the subcategories. The sum of one subcategory (e.g. supportive laws) can be compared to the other subcategories (e.g. certification) to analyze which subcategories are most frequently available. Afterwards, an availability pattern between carrots, sticks and sermons can be prevailed based on total occurrences (see table 4, on page 27).

5. Results of literature analysis of policy instruments

5.1 Sticks: Existence of regulatory instruments within the availability framework

5.1.1 Laws, targets and certification constitute the stick categorization

Sticks (formalized rules) were defined into four categories: law supportive, targets and certification and restrictive laws (figure 3). In total eighteen examples of formal regulations were found based on the literature review. Of these eighteen, nine of these examples are supportive laws. In this instance, supportive laws primarily relate to the legislation of additional demands within the procurement process and the obligatory disclosure of public procurement innovation plans. Important is to note that standards and directives set by the World Trade Organization (WTO), International Organization for Standardization (ISO) and the European Commission (EC) are not included in the total occurrences table but are widely accepted. No systematic combinations are found within countries (i.e. a country that does have a restrictive law does not necessarily not have a supportive law, and certification is for example not a substitute nor a complement of a supportive law). Sections 3.2 till 3.6 explain innovation instruments categorized into these four categories more in detail.
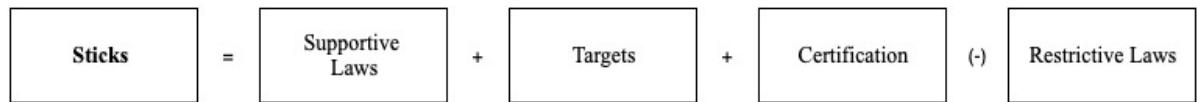
Figure 3: sticks framework

5.1.2 Worldwide agreements and directives that regulate procurement of innovations

A 'stick' instrument that is not specifically linked to a country, but rather to a worldwide formalized instrument, is the 'Agreement on Government Procurement', set by the World Trade Organization. This agreement ensures *"open, fair and transparent conditions within government procurement markets"* (WTO, 2019). This treaty is internationally binding for 20 WTO member countries, whereas another 34 members (i.e. countries) participate as observers. This 'Agreement on Government procurement' was revised and entered into force in 2014, however, the fist agreement on government procurement exists since 1981 (WTO, 2019). The International Standards Organization provides comparable standards as the World Trade Organization, which are also widely accepted (OECD, 2017a, p.81).

The European Commission's (EC) directives are based on the current WTO agreement (Georgiou et al, 2014, p.3). From 18 April 2016 onwards, countries of the European Union have to conform their national legislation with the newest version of these directives (European Commission, 2016a). Within these new EC directives are the innovation partnership, pre-commercial procurement (PCP), and procurement of innovative solutions (PPI). The innovation partnership constitutes of a competitive phase (finding the most suitable partner), the R&D phase, and the commercial phase. This procedure allows for a simplified process combining both the development and purchase of products (European Commission, 2016d). Compared to the innovation partnership, PCP solely focuses on the R&D phase. Hence, PCP procedure can be used for procuring innovative products and services that have no near-to-the-market solutions yet, and R&D is needed. For a PPI, there are near-to-the market solutions, hence, no new R&D is needed (European Commission, 2019a). Within PPI, the *"public sector uses its purchasing power to acts as early adopter of innovative solutions"*, thus solely focusing on the commercial phase (European Commission, 2018c). PCP, on the other hand, is a development competition with four phases: design, prototyping, development and testing. It starts with several suppliers competing in parallel for the best solution for the market. The number of suppliers is reduced after each phase (European Commission, 2018b). PCP is thus complementary with PPI

(European Commission, 2018c). Additionally, from October 2018 onwards, the use of e-procurement will be mandatory for all EU member countries (European Commission, 2016b).

5.1.3 Restrictive laws: Exclusion from bidding and non-existed infrastructure constraints procurement of innovations

Within the restrictive laws, two examples are found in the 23 countries. Article 78, in the Belgium Law entails that suppliers of the prototype are excluded from bidding on supplying the innovative product (Georghiou, Edler, Uyarra & Yeow, 2014, p.4). On the other hand, the Lithuanian government does not specify one restrictive law but is restrictive in the sense that it does not offer supportive laws. In Lithuania, the existing legal relation does not facilitate the development of innovative products through public procurement, it for example, does not have a model for pre-commercial procurement, as described in the European Directives (OECD, 2017a, p.127).

5.1.4 Supportive laws: Obligatory disclosure of procurement plans and legislation of additional demands support procurement of innovations

Supportive laws are the largest subcategory within the 'sticks' category. In total, nine examples are found. In the Belgium National Procurement act, article 87, the Belgium government specifies the following: *'the contracting authority may attach special conditions to the contract, provided that they are related to the subject of the contract [...] These conditions may relate to economic, innovation, environmental or social or labor-related considerations'*(Public Procurement BE, 2016). Similarly, the German government also allows for the imposition of additional demands upon suppliers, including requests for innovations (Rammer, 2011, p.16). The "MEAT" (most economically advantageous tender) criteria of Portugal, implemented in the Public Contracts Code of 2008, also allow for special conditions such as innovations in addition to price (OECD, 2017a, p.83,143). Additionally, the Public Contracts Code mandates the use of e-procurement and allows for green award criteria (OECD,2017a, p.143). Hence, one form of supportive regulation is the legislation of enforcing additional demands.

More broadly, New Zealand introduced the 'government rules of sourcing' which includes rules for sustainable and inclusive procurement through 7 sections and 71 rules (Ministry of

Business Innovation & Employment New Zealand, 2019a). An example of such a rule is rule 20: '*transitioning to a net-zero emissions economy and designing waste out of the system'*. These rules will be officially enacted from the first October onwards and aim for continuous innovation, requiring high standards in the procurement processes (Ministry of Business Innovation & Employment New Zealand, 2019a, p.37). A different type of supportive law is enacted by France. France established legislation allowing for price premiums to be offered to provide preferential treatment to innovative SME's (Zaparucha & Muths, 2011, p.14).

In Russia, innovation is ensured through law in two-fold. Firstly, state-owned enterprises are obliged to procure innovation based on their percentage of shares (OECD, 2017a, p.147). Secondly, state-owned enterprises also have to disclose their agenda for procuring innovations (OECD, 2017a, p. 147). Relatively similar are the 'white paper innovation nation' initiative of the UK, and the regulation for public procurement of innovation of Spain. While the white paper innovation is terminated, the initiative mandated ministries to disclose an Innovation Procurement Plan (DIUS, 2008, p.3). Similarly, Spain's existing regulation, mandates all ministries to define a budget for procurement of innovation (OECD, 2017a, p.150).

Korea takes the initiatives of the Russia, UK and Spain one step further by specifying the percentage that should be spend on procurement of innovations. In one of the nine policies focused on procurement of innovation, the Korean government specifies the following: *'enterprises should fulfill 20% of procurement with innovative procurement'* and '*new technology-certified products are expected to account for 20% of the procurement of a specific product type'* (OECD, 2017a, p. 125). Similar to this policy is the technology development preferential purchase policy. Among others, this policy mandates that ten percent of all SME-product purchases should be spend on developed technology products (OECD, 2017a, 125).

5.1.5   Increasing procurement of innovation through target setting

Whereas Korea sets strict laws on percentages specified for public procurement of innovations, other countries document targets in their government declarations. The city of Ghent (Belgium), for example, introduced a city target in 2014 for its ICT procurement, aiming for ten percent of its budget to be spend on innovation (European Commission, 2014a). Lithuania defined its target as a percentage of total procurement. Whereas in the base year, 2012, 1.17 percent of total procurement was spent on procurement of innovations, the ministry of

Economy targets for two percent in 2017 and five percent in 2020 (Government of the Republic of Lithuania, 2013). Similar to Lithuania, Russia set its target for 2017 at 2.5 percent for procurement of innovations, with the aim to increase it to five percent in the future and Spain's target is currently set at three percent (OECD, 2017a, p.147).

5.1.6 Certification: Labeling of innovative products and services as a strategy to provide advantages that support the procurement of innovations

Korea offers in total nine policies on procurement of innovation, categorized by direct support (4 policies), indirect support (3 policies) and R&D support (2 policies), which to some all extent use certification (Choi, Lee & Lee, 2014, p.99-100). This certification implies that a certain product, service, or firm is labeled as innovative (different certification based on different categories), giving it various advantages. These advantages include immunity for losses, access to sales channels, guaranteed governmental reputation, and direct purchasing opportunities (OECD, 2017a, p.125). China's strategy is similar: national innovation certification serves as a label of high demand, indicating that those technologies or products should have priority on financial incentives (Li, 2011, p.13-14). Another certification method is used in the UK, where the use of certifications serves as quality label within public procurement to reduce uncertainty in UK institutions. An example is the National Health Service (NHS), which uses specified demonstration procurement procedures (Yeow & Edler, 2012, p. 485-488).

5.2 Carrots: Existence of materialistic instruments within the availability framework

5.2.1 R&D funding, expertise funding, after-care funding and non-specified government budgets constitute the carrot category

Whereas sticks revolve around formal regulation, carrots revolve around the economic means or materialistic resources (Bemelmans-Videc, Rist & Vedung, 2003, p.10). Hence, whereas a supportive law (stick) is a rule that has to be complied with, a carrot can be a financial incentive that is voluntary applied for. The category carrot constitutes of four subcategories; (1) R&D funding, (2) Expertise funding, (3) after-care and (4) non specified budgets (Figure 4). 'Not specified' relates to governments who indicated a budget for public procurement of innovation but did not specify how that budget should be spend. In total 25 examples of materialistic resource instruments were found based on the literature review. Of these 25, 16 of

these examples were focused on R&D funding, which is over sixty percent. In this instance, R&D funding mostly relates to innovation challenges (almost 60%), and co-financing (over 20%). Besides R&D funding instruments (64%), materialistic resources are also available in terms of expertise funding (20%) and funding for after care (20%). Furthermore, additional funding can be retrieved through European funds such as Horizon 2020.In the sections below, the instruments that belong to these categories are discussed.

| **Carrots** | = | R&D funding | + | Expertise funding | + | After-care funding | + | Unspecified buget |
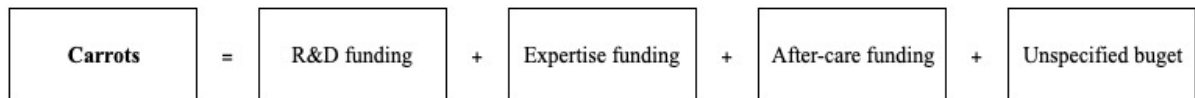
Figure 4: carrots framework

5.2.2   European Commission initiatives support procurement of innovations

Beside the materialistic resources that are made available through country budgets, there is also public procurement innovation funding available through the European Union. This is mainly through two funds: Horizon 2020—part of Europe 2020, the innovation union—and the European Regional Development Fund (ERDF). To date, horizon 2020 is the biggest research and innovation program, budgeting close to eighty billion of funding from 2014 till 2020 (European Commission, 2018a). Within this budget, 142 million is allocated to procurement of innovations (European Commission, 2014b). This procurement of innovations is done through pre-commercial procurement (PCP) processes or through public procurement of innovation (PPI) processes (European commission, 2014b). One can either get funding to undertake the PCP or PPI, or to identify opportunities and prepare future PCP's or PPI's (European Commission, 2014b). Through synergies with Horizon 2020, the European Structural and Investment Funds (ESIF) can provide additional support. Existing since 1975, one of the components of the ESIF is the European Regional Development Fund (ERDF) (European Commission, 2019b). These funds provide financial means for structural development and adjustments of economies. Procurement of innovations could be seen as development, hence the opportunity for financial support. One example is the 'Innovation purchasing program' of Estonia, which is financed through the ERDF fund (Republic of Estonia, 2019).

5.2.3 R&D funding: Existence of materialistic research and development instruments within the availability framework

5.2.3.1 The availability innovation challenges and other R&D funding instruments

The largest subcategory within the category carrots is research and development funding. R&D funding can be done through innovation competitions (SBIR, Challenges and Pre-Commercial-Procurement), or through co-financing, innovation awards, insurances, catalogues or pre-specified contracts (figure 5). Most frequent are the innovation competitions in the form of Small Business Innovation Research (SBIR). Appendix I provides a frequency table of the number of occurrences within each subcategory of R&D funding. In total nineteen examples of R&D funding instruments were found based on the literature review. Which, as a subcategory, is comparable to the main category of sticks, which had eighteen occurrences. The biggest category is SBIR, which comprises almost 32 percent of this subcategory. However, innovation competitions as a whole (SBIR+ Challenges+ PCP) comprise of almost sixty percent of all R&D funding opportunities.
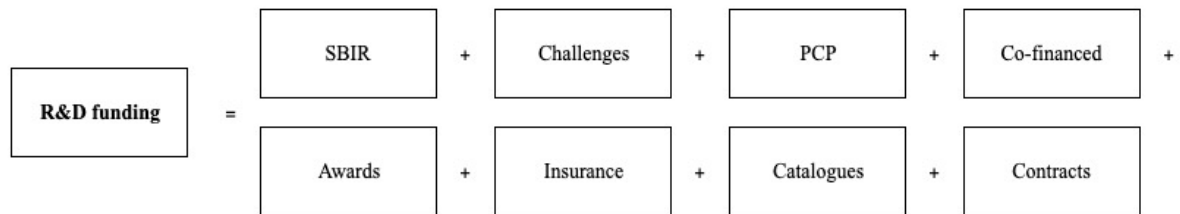
Figure 5: R&D funding framework

5.2.3.2 Six countries use Small Business Innovation Research (SBIR) to increase the procurement of innovations

Small Business Innovation Research (SBIR) originates from the United States, where it was first introduced in the seventies, as a response to the competitiveness crisis (Audretsch, 2003, p.130). The idea was that in order to restore the competitiveness of the United States, four percent of the annual budget should be spent on funding small innovative companies (Audretsch, 2003, p.132). Currently, a similar rule applies, as 3.2 percent of the R&D budget should be spent on SBIR, under the condition that the budget of a federal agency exceeds a hundred million US dollar (SBA, 2019). Over one billion is spent each year on this competitive awards-based program (Audretsch, 2003, p.132). SBIR comprises of three phases: (1) feasibility study, (2) development phase and (3) the to the market phase. The first phase lasts for six months and

funding in this phase cannot exceed 150 thousand US dollars. Afterwards, approximately forty percent proceeds to the second stage, where funding is limited to one million US dollars. The last phase, commercializing the product is done through private sector investments (SBA, 2019). After successfully passing the SBIR process, funding is still available through public venture capital funds (Block, 2008, p.191).

While the SBIR originated in the United States, other countries adopted similar competitive awards-based programs. In Ireland, 'Enterprise Ireland' adopts a SBIR program, using PCP, which resulted in 11 challenges in 2018 (Enterprise Ireland, 2019). Similarly, the Netherlands adapted the "*US experience*" with the "*EU vision*". The process is identical to the US, hence the US experience, but it is accessible for all companies, hence the EU vision (Tweede Kamer, 2017). Similar to Ireland, the Dutch variant is mostly focused on pre-commercial procurement. Current projects include circular innovations of waste and historical transcription with artificial intelligence (Rijksdienst voor Ondernemend Nederland, 2019). Compared to the US, the scope is smaller: 58 calls in twelve years with a total budget of 102 million (Tweede Kamer, 2017). Similar to Ireland and the Netherlands, is the Small Business Research Initiative (SBRI) of the United Kingdom, led by 'Innovative UK'. The SBRI also combines the US program with the EU rules for PCP (OECD, 2017a, p.163). The Australian variant is called 'Business Research and Innovation Initiative' (BRII). BRII annually budgets two million Australian dollars for feasibility studies (a maximum of a hundred thousand per project) and ten million Australian dollars for proof of concept (maximum of a million each) (Australian Government, 2019). Larger of scope is the Korean Small Business Innovation Research program (KOSBIR), where both the process and the budget are similar to the US's SBIR (Lee & Jo, 2018, p. 49). Over fifteen percent of Korean's government budget for research and development was spent on KOSBIR, equaling almost three thousand billion won (2.5 billion US dollars) (Lee & Jo, 2018, p.49). Hence, in total, six country out of 23 countries used a form of the SBIR programs

5.2.3.3 Innovation Challenges: Governments' expressions of interest list allow for competitions towards innovative solutions

The second subcategory within R&D funding is the 'innovation challenges'. Whereas the SBIR programs are competitive award-based programs with three specific phases, other countries make use of innovation competitions without pre-specified phases, usually referring

to them as 'challenges'. One example are the challenges on the 'Innovationsförderende öffentliche beschaffung' innovation platform, tendered by the Austrian government, where the budget and pre-requisites depend on the project (IÖB, 2019a). Examples of current projects include 'green lines: new roads with green waiting areas' or 'new E-loading infrastructure for lower Austria' (IÖB, 2019b). Similarly, Innovative Solutions Canada has an annual budget of a hundred million CAD to procure innovations, which are spread out over challenges that appear throughout the year (Government of Canada, 2019). Alike, in Spain the Centre for the Development of Industrial Technology, has a published 'call of expressions of interest' for innovative solutions, aiming for solicited proposals (CDTI, 2019).

5.2.3.4 Italy's and Greece's pre-specified PCP budgets allow for innovation competitions

Both Greece and Italy allocated a budget for pre-commercial procurement programs. PCP is a European development competition with four phases: design, prototyping, development and testing. It starts with several suppliers competing in parallel for the best solution for the market. The number of suppliers is being reduced after each phase (European Commission, 2018b). Whilst there are no specific challenges pre-specified, the usage of the PCP method is competitive in its origin, which makes it an innovation competition similar to SBIR and the challenges (European Commission, 2018b). Initiated by the Ministry of Education, Research and Religious affairs of Greece, in collaboration with the General Secretariat for Research and Technology (GSRT), is the RIS3 2014-2020 strategy, which includes a forty million EUR budgeted program on PCP (OECD, 2017a, p.117). In a likewise manner, the Italian Ministry of Education corporates with the Digital Italy Agency (AgID), to offer multiple PCP programs with a total budget of a hundred million EUR (OECD, 2017a, p.123).

5.2.3.5 Co-Financing: Shared financing to increase innovation opportunities

Besides innovation competitions, other governments opt for co-financing (i.e. shared financing) procedures. The Belgium government initiated the 'Program Innovative Public Procurement' (PIO), which solely focuses on co-financing. The total budget is five million EUR annually, with no pre-specified maximums per project. The average of an R&D project, however, is one million euro (PIO, 2019a). Estonia's 'Innovation purchasing program', financed

with the European Regional Development Fund (ERDF), has a total budget of eighteen million EUR, of which fifty percent has to be self-financed. Furthermore, Estonia does have a maximum per project, which lies on five-hundred thousand EUR of funding (EAS, 2019a). In Germany's Central Innovation Program for SMEs (ZIM), the ceiling lies at 350 thousand EUR per project for R&D costs, which is non-repayable and only available with shared financing (KOINNO, 2019a). In Spain, the two programs 'Innodemanda' and 'Innocompra' facilitated a quarter of all the procurement for innovations using the shared financing principle (OECD, 2017a, p.151). The latter, 'Innocompra' is a co-financing program that makes use of the ERFD fund, which had over twenty successful innovations, realizing over 230 million EUR (OECD, 2017a, p.151; CDTI, 2019).

5.2.3.6 Awards, insurance, catalogues and contracts as additional instruments to provide materialistic resources for innovations

Within the sample of 23 countries, only one country had an 'procurement of innovation award'. Each year, the German Competence Centre, KOINNO, has an award ceremony for both the best 'innovative procurement', as well as the best 'procurement of innovation', awarding ten-thousand EUR to each (KOINNO, 2019b). Similarly, only one country makes use of insurances. In Korea, insurance is provided for certified R&D products, to ensure sale opportunities and price assurance (Choi, Lee and Lee, 2015, p.99-100; OECD, 2017a, p.125). Specifically, the New Technology Purchasing Assurance Scheme rewards insurance for losses by providing a fixed price assurance as well as a fixed purchasing assurance (Edler et al., 2005, p.154). This insurance combined with certification also serves as a reference for buyers (OECD, 2017a, p.125).

The 'innovation catalogues' of China, are also an instrument only found in China, mostly used in municipalities. The catalogues consist of one equipment catalogue and one innovation catalogue. The equipment catalogue is a top-down list, indicating what the government wants (enforcing a push mechanism). If companies can develop such innovations, they will be provided with financial measures such as subsidies and tax reduction. If the innovation is successfully developed, it will be listed on the innovation catalogue—i.e. the 'what we have list'—and eliminated from the 'equipment catalogues'. Hence, together the catalogues work in two directions, both push and pull (Li, 2011, p.13-14). In Russia, innovation contracts are in

place, in which *"suppliers are paid for the final results that they achieved according to clear and measured indicators of the final effects"* (OECD, 2017a, p.147).

5.2.4 Expertise Funding: Innovative consulting reimbursement to support innovative ideas

Besides materialistic resources for research and development of innovative solutions, government can also offer expertise funding in terms of purchasing new knowledge. In Austria, the Innovationsfördernde Öffentliche Beschaffung (IOB) prepare, offers full financial support in terms of consulting costs for the design and implementation of IOB challenges. The maximum per project is set at fifteen thousand EUR (IÖB, 2019a). The federal ministry for Economic Affairs and Energy in Germany offers similar services, where within the Central Innovation Program for SMEs (ZIM) a maximum of fifty thousand EUR per project is made available for innovation-supporting services and consultancy (KOINNO, 2019a). Belgium's 'program innovative public procurement' has a budget of five million EUR annually, which can be used for either R&D, pilot projects or external expertise. All options should be financed by co-funding. Whilst there is no maximum per project, the government does indicate an average per project, which is set at thirty thousand EUR for external expertise (PIO, 2019a). Lastly, the Finnish government provides 'innovation vouchers', which can be used to "*purchase new knowledge and skills"* (Business Finland, 2019).

5.2.5 After care funding: Materialistic resources for market implementation to spur innovation

Austria, Belgium and Korea offer services in promoting the procured innovative projects. In Austria, the Innovationsfördernde Öffentliche Beschaffung (IOB) transfer, offers co-financing support in terms of investing in the promotion of innovative projects, with a maximum of a hundred thousand EUR a project, of which fifty percent needs to be co-financed (IÖB, 2019a). Out of the five million EUR annually offered by the co-financed 'Program Innovative Public Procurement' in Belgium, an average of one million EUR per project is spend on pilot projects— with no specific maximum per project (PIO, 2019a). In Korea, one policy is focused on marketing innovation. Within this policy, the government helps to; set up sales channels, support the initiation of pop-up stores, and financing marketing and global research (Choi, Lee and Lee,

2015, p.99-100; OECD, 2017a, p.125). Similarly, the Market Development Fund in Denmark, focuses on the early development phases of innovative products, taking over after the R&D programs stop, to assist final adaptation of innovation solutions using PCP and PPI (Markedsmondingfonden, 2019a; 2019b)

5.2.6 Sweden's budget for innovations without a pre-specified purpose as an instrument to increase procurement of innovations

'Not Specified' relates to governments who indicated a budget for public procurement of innovation but did not specify how that budget should be spend, which was the case for Sweden. Identified national competence center 'Upphandlings myndigheten' (translated as procurement authority) indicates that state-aid is used to support innovative operations with public funds. It does not, however, specify a budget, nor does it provide specific instruments (Upphandlings myndigheten, 2019a).

5.3 Sermons: Existence of knowledge transfer instruments within the availability framework

5.3.1 Competence centers, newsletters & events, consultancy & training, guides constitute the sermon category

Sermons are classified as instruments that provide the transfer of knowledge (Bemelmans-Videc, Rist & Vedung, 2003, p.11). Within this categorization, four different subcategories emerged: (1) competence centers & innovation platforms, (2) newsletters & events, (3) consultancy and training, (4) guides, manuals and best practices (Figure 6). In total 49 different instruments are explained within this chapter. 15 of these examples are either guides, manuals or best practices, which makes it the largest category within 'knowledge transfer'. Whereas 'consultancy and training' is the least used category in this sample size, it is still used by forty percent of the sample size. Next to country-specific instruments, there are also instruments that are not country-specific that should be considered, such as United Nations training and the European Assistance for Innovation Procurement Initiative (EAFIP). The following sections provide a more detailed overview of the instruments within this category.

Figure 6: sermons framework

5.3.2 The United Nations Development Program and the European Commission tools offer knowledge transfer instruments worldwide

Besides instruments found on a domestic scope, sermons are also available on a global scale, such as the European Commission initiatives and United Nations Training. The latter is called the 'United Nations Development Program' (UNDP), which offers training and certifications at different levels for everyone involved in public procurement (UNDP, 2019). Whilst there are four levels of certification, also tailor-made courses exist for governments and international organizations. Additionally, training exist in themes such as ethics, anti-corruption, sustainability, and risk-management (UNDP, 2019). Among others, the European Commission provides the EAFIP (European Assistance from Innovation Procurement Initiative), which provides training, free legal assistance, free technical assistance, shared best practices, events, video lessons, an online help desks and local assistance (European Commission, 2015). On a broader scale, the European Commission also offers eCertis as a reference tool, which informs firms about the formal regulation and certificates requested in specific procurement processes (European Open Data Portal, 2018). Next to this, the European Commission additionally offers a guidance document on public procurement in innovation, an innovation platform (including a forum and recourse center), workshops, conferences, a DG Connect Innovation Procurement Newsletter, and an open LinkedIn group (European Commission, 2014c; 2019a; 2019c).

5.3.3 Competence centers and innovation platforms as a starting point for encouraging innovations through procurement

A competence center on procurement of innovations is an organization that originates from the government, with the sole aim of encouraging procurement of innovations (Procure 2 Innovate, 2019a). Originating, and partially funded by Horizon 2020, is the 'procure 2 innovate' program in which competence centers will share knowledge, collaborate and exchange best practices. Joint procurement, cross-border learning and increasing the usage of PCP and PPI are also within the main objectives (Procure 2 Innovate, 2019a).

In this program, ten countries are involved, five of which already have existing centers and five of which are under construction. Already existing competence centers are Austria (PPPI service centre), Germany (KOINNO), the Netherlands (PIANOo), Spain (CDTI), and Sweden (National Agency for PP). The five competence centers under construction include: Estonia (Enterprise Estonia), Greece, Ireland (PTI), Italy (CONSIP), and Portugal (ANI) (Procure 2 Innovate, 2019a; 2019b; 2019c; 2019d; 2019e; 2019f; 2019g; 2019h; 2019i; 2019j; 2019k). Whereas most programs also offer information about economic instruments, the basis mostly lies in the transfer of knowledge. Whilst all ten of the competence centers are within the same program, it does not indicate that all ten competence centers provide the same information and services. The Dutch competence center, PIANOo, is appointed national expertise center by the Dutch government. The website provides advice, information, instruments and practical tips to everyone involved the public sector, with the aim of improving compliance and efficiency to the Dutch procurement rules (PIANOo, 2019a). Whilst KOINNO (Germany) for example, offers inhouse training and individual consultation sessions (KOINNO, 2019c). A more elaborate overview of the services provided by the national governments and competence centers is given in the following sub-categories.

Whilst France, the UK and Belgium are not part of the 'procure 2 innovate' program, they do have competence centers. The Belgium 'Program Innovative Public Procurement) (PIO) competence center offers information and advice, guidance on innovation projects and provides information about financing (PIO, 2019a). In France, an internet platform is created to offer services such as a help desk, best practices, relationship facilitation and process clarification (OECD, 2017a, p.112). Additionally, the French competence center facilitates networking and awareness and tries to reduce time and risk by creating an innovation unit (OECD, 2017a, p.112). Innovative UK offers an innovation platform which contains funding advice, events, connection to a funding expert and funding opportunities (Government UK, 2019). Whilst Portugal is connected to the 'procure 2 innovate' program with its competence center ANI, Portugal also offers another procurement platform called BASE which is related to innovation but not specifically for innovation. On this platform, one can find guides, good practices, and FAQ's (BASE, 2019).

5.3.4 Distributive instruments such as newsletters and events to increase procurement of innovation awareness

With the exception of Spain, all competence centers within the 'Procure 2 innovate' program offer either newsletters or events, or both. Austria (PPPI service centre) offers both newsletters and networking events, such as the IOB Bundeslandertag, or 'Impact Innovation' event (IÖB, 2019c). In Germany (KOINNO), events such as regional conferences, seminars, trade fairs and innovation venues are organized (KOINNO, 2019d). Whereas PIANOo (the Netherlands) holds an annual congress, regional events and market consultations (PIANOo, 2019b). The Swedish government provides workshops and a magazine (Upphandlingsmyndigheten, 2019b; 2019c). In Estonia, seminars and conferences are held (EAS, 2019a; 2019b). In 2016, the European Assistance for Innovation Procurement (EAFIP) event was held in Greece (Promitheus, 2016). Currently, Greece offers awareness workshops on PPI and PCP (Procure 2 Innovate, 2019l). PTI Ireland offers both events and a weekly newsletter (PTI, 2019a; 2019b). Likewise, CONSIP Italy, Innovative UK and ANI Portugal offer different events annually (CONSIP, 2019a; ANI, 2019a; Government UK, 2019). The Belgium competence center offers information sessions as well as a newsletter (PIO, 2019a). France, on the other hand, focus is on promotional events to increase networking and awareness (OECD, 2017a, p.112).

5.3.5 Consultancy and training: E-learning, courses and certificates to increase understanding

Most of the 'procure 2 innovate' competence centers offer either consultancy or training or both, with the exception of Greece, Spain and Portugal. On the innovation platform of Innovative UK, one can connect for example with a funding expert, whereas one can follow sustainability and circular procurement training in the Netherlands (PIANOo, 2019c; Government UK, 2019). Additionally, the Netherlands also offers webinars and videos (PIANOo, 2019d). Austria offers both training and strategic PPPI consultancy, whereas Germany offers in-house training, seminars, e-learning and individual consultations (IÖB, 2019d; KOINNO, 2019e; KOINNO, 2019f). In Sweden, YouTube videos and online courses are offered such as a training on life-cycle-costs within public procurement (Upphandlingsmyndigheten, 2019d). Likewise, Consip (Italty) also offers online training courses, such as in negotiation, creation of contracts, and using the purchasing portal (CONSIP, 2019a). In Estonia, training is also offered, but no specific courses or events are currently

specified (European Commission, 2016c). In the Irish competence center, the learning opportunities are in three-fold. The competence center offers training in collaboration with higher education organizations, whilst developing Continuous Professional Development (CDP) courses (PTI, 2019c). Thirdly, through a partnership with University College Cork, a one-year level eight certificate of Procurement Management is offered at the Procurement Transformation Institute (PTI, 2019d). In New Zealand, the commercial pool provides expert assistance for implementation of large, complex procurements, while also offering online training, courses, and mentoring (OECD, 2017a, p.134-135).

5.3.6   Guides, manuals, handbooks and best practices to increase procurement of innovation accessibility

The largest category within the 'knowledge transfer' category are the guides, manuals, handbooks and best practices. 16 out of 23 countries make use of such instruments (table 9). New Zealand for example, offers a guide and templates on how to procure for innovations (Ministry of Business Innovation & Employment New Zealand, 2019b). In the United States, practical tools, best practices, practice tips are all combined in one handbook called the TechFar (Federal Acquisition Regulation) (TechFar, 2019). The TechFar consists of principles that regulate public procurement. Within the handbook, flexibilities within the regulation are emphasized using laymen terms (TechFar, 2019). In Denmark, procurement of innovation is part of the "strategy for intelligent public procurement" (OECD, 2017a, p.103). Within this strategy, 29 concrete actions are taken, including one action that relates to providing guidance on the functional requirements within innovation, and one that distributes best practices of procurements of innovations. Those 29 actions are built on the seven guiding principles of public procurement, of which number 4 states: "*always consider using functional requirement to support innovation and development of more efficient solutions*" (OECD, 2017a, p.104).

In Portugal, the competence centre ANI offers a Q&A section on questions related to procurement of innovations, whereas the procurement platform BASE offers a public procurement guide—with an innovation section—and good practices—with innovation examples (BASE, 2019; ANI 2019b). The UK guides, on the other hand, focus on how to receive and apply for public procurement innovation funding (Government UK, 2019). Next to Innovative UK, the Local Government Association of Wales and England, also offers policy guidance and best practices lead by the National Advisory Group, focusing on strategic and

regional procurement with specific interest in innovation (Local Government Association, 2019). In Belgium and Estonia, on the other hand, the guide on procurement of innovation is still in development (PIO, 2019b; European Commission, 2016c).

In Austria, the indicated pilot projects serve as a guide for best practices (IÖB, 2019d). In the German competence centre, guides, practical examples and a toolbox can be found (KOINNO, 2019g). PIANOo (the Netherlands) offers guidelines, sample documents, research, advice documents and practical examples on procurement of innovation (PIANOo 2019d; 2019e). In Spain, a guide on procurement innovation exists, focusing on demand-side innovation, with in specifically pre-commercial procurement and innovative technology of public procurement (OECD, 2017a, p.150). In Ireland, information is mainly provided through a forum, whereas Greece mainly focuses on user-manuals, and Italy on guides (PTI, 2019e; Promitheus, 2019; CONSIP, 2019b). In Sweden, a criteria library is designed, articles are frequently published and there is a Q&A forum (Upphandlingsmyndigheten, 2019e). Subsequently, there is a section of the webpage specifically for 'supplier in procurement' information, which also contains information on preparing tenders and submitting tenders for innovation (Upphandlingsmyndigheten, 2019f).

6. Discussion: Cross-analysis of available public procurement policy instruments

Within the previous chapter, public procurement innovation policy instruments where categorized and explained. Which led to the availability framework presented in figure 7. Similarly, a frequency table was made based on the availability of an instrument in a country, the complete frequency table can be found in table 4.
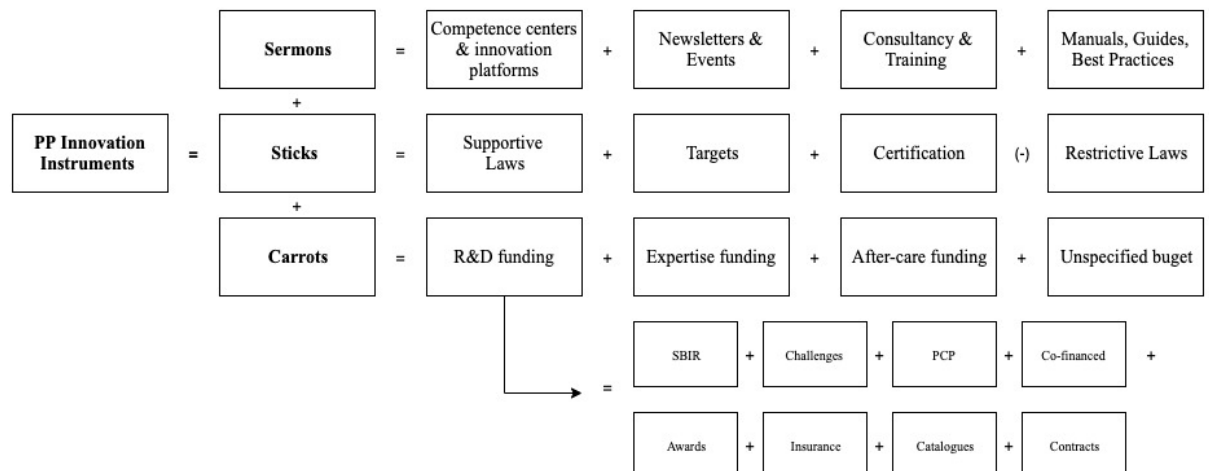
Figure 7: the availability framework

Within the categorization of sticks, carrots and sermons, twice as many sermon instruments (49) are found compared to sticks (18) and carrots (25) combined. On the subcategory level—with the exception of unspecified budgets—restrictive laws and certification are the subcategories which are not frequently found. R&D funding on the other hand, is the most frequently available instrument. In conclusion, sermon instruments are most frequently found (49 times) whilst R&D funding is the largest subcategory in terms of availability (16 times). However, availability does not indicate any usage nor effectiveness pattern. Another pattern exists between European and non-European countries. Ten out of 23 countries had over five instruments available, all those countries are part of the European Union. Additionally, nine of those are part of the procure 2 innovate project. Of the procure 2 innovate project, only Portugal has less instruments available. This could be due to the fact that the competence centre ANI is still under construction.

Country	Guides	Consultancy	Newsletters/events	Competence center	Not specified	After care	Expertise	R&D	Certification	Target	Law supportive	Law restrictive	Total
Australia								X					1
Austria	X	X	X	X		X	X	X					7
Belgium	X		X	X		X	X	X		X		X	8
Canada									X				1
China	X							X					2
Denmark						X		X					2
Estonia	X	X	X	X			X						5
Finland											X		1
France			X					X			X		3
Germany	X	X	X	X			X	X			X		7
Greece	X	X	X	X									4
Ireland	X	X	X	X		X		X					5
Italy	X			X				X	X		X		5
Korea	X							X		X	X		4
Lithuania												X	1
Netherlands	X	X	X	X				X					5
New Zealand		X		X				X					3
Portugal	X		X	X							X		4
Russia								X		X	X		3
Spain	X	X	X	X				X			X		5
Sweden	X	X	X	X	X				X				5
UK	X		X	X				X	X	X	X		7
US	X							X					2
Total	15	9	12	13	1	4	4	16	3	4	9	2	90 (92)

Table 4: frequency table PP innovation policy instruments

7. Step 2 – Introduction: Validating the framework through experts' expertise

The second step in this research is to validate the framework that was drafted using government websites and literature, by integrating public procurement experts' expertise (figure 8). This validation took place at an international research study of public procurement, with this year's theme: public procurement of innovation. The research study is an invitation-only event. This validation is important to ensure that the framework is complete and correct before the framework and instruments can be analyzed.
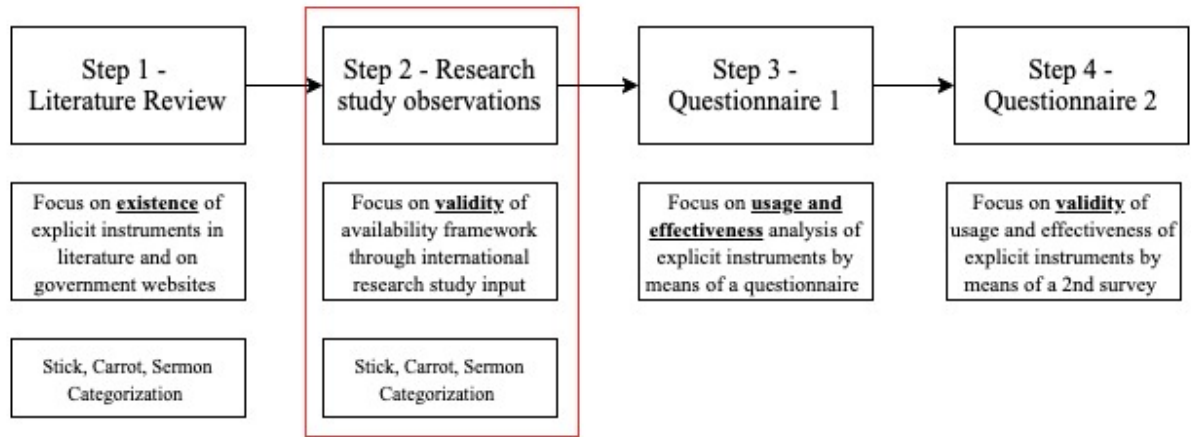
Figure 8: the research approach

The international research study consists of three elements, (1) presentations by the organizing committee, (2) case studies on public procurement of innovation projects and instrument availability by country representatives (i.e. participants), and (3) sense-making and cross analysis of all gathered data. 23 participants-of 15 countries—were present at the international research study, of which 16 case-study were presented (table 5).

1. Argentina	2. Belgium	3. Canada	4. Germany	5. Hungary
6. Indonesia	7. Italia	8. Netherlands	9. Norway	10. Poland
11. Scotland	12. Slovenia	13. Wales (2x)	14. US	15. Zimbabwe

Table 5: countries represented at the international research study

During the first half of the first day of the three-day research study, the initial framework based on the literature review conducted in this study was presented. This ensured familiarity with the framework before the start of the research study. During the next one and a half day, participants presented their own innovation projects according to a semi-structured template made available by the organizing committee (appendix II). Within this template, participants were asked to provide information about the availability of public procurement innovation policy instruments within their country of residence. Similarly, during the sense-making and

cross-analysis, instrument availability was discussed by the country representatives. Researcher interpretation on the data of instrument availability from the cross-analysis and case-studies combined was used to validate and adapt the previously formed framework. Based on the interpretation of the researcher, two categories were not covered in the previous framework: (1) government declarations and actions plans, and (2) unsolicited proposals. Government declarations and action plans refer to the amount of attention that public procurement of innovation gets in official government declarations and action plans, whereas unsolicited proposals refer to supplied proposals which are not asked for by the government, but nevertheless provide new opportunities and added value. Hence, it is a supply-side instrument. Whereas unsolicited proposals are not within the scope of this study, as it is a supply-side instrument, the researcher argued it gained significant attention during the international research study and should therefore be further analyzed as an innovation instrument. Only after the verification and adaptation of the developed framework, the usage and effectiveness questionnaire (step 3) was distributed. Consequently, government declaration plans and unsolicited proposals are included in both the questionnaire (explained in step 3) and in the new framework (developed in step 1).

8. Step 3 – Introduction: Qualitative Comparison Analysis (QCA) on usage and effectiveness of public procurement innovation instruments

The third step in this study is to find evidence on the usage and effectiveness of the previously categorized instruments through the means of a survey distributed among public procurement experts (figure 9). The analysis will be done with QCA. This step is important since the economic significance of public procurement results in an increased potential of public procurement for secondary policy objectives, such as innovation (OECD, 2017b, p.174). Missing is however the evidence of the benefits and effectiveness of such policies and strategies (OECD, 2017a, p.42). Whereas 83 percent of the OECD countries have developed a strategy for innovative goods or services, merely 32 percent of the countries have a measurement system for 'innovative goods and services' (Magina, 2019, p.4-6). Hence, the lack of a measurement system indicates a missed opportunity in terms of evidence of the benefits and effectiveness of such innovation policies. Accordingly, this thesis aims to reduce this discrepancy by sketching an

overview of the utilization and effectiveness of innovation policy within public procurement by asking

RQ2: *Do patterns in public procurement innovation policy instruments prevail in terms of usage?*

RQ3: *Do patterns in public procurement innovation policy instruments prevail in terms of effectiveness?*

The methodology will be presented in chapter 9, and the results in chapter 10. The discussion of the results will only be presented after the validation of the research, after step four.
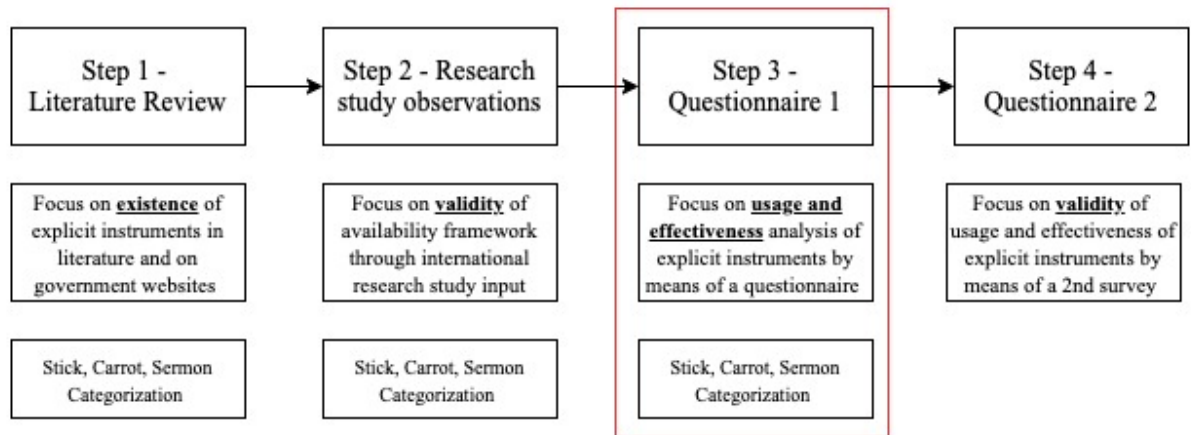
Figure 9: the research approach

9. Methodology: Analysing the usage and effectiveness of instruments through QCA

9.1 Sampling: analysis is based on public procurement experts selected as country representatives

The questionnaire (appendix III) is distributed to research study participants and (previous) research study invitees, which is on an invitation-only basis. This ensures that participants are active in public procurement and are within a function that ensures they have knowledge of the subject. Participants are within one of the following roles of public procurement: CEO, CFO, CPO, Director of Procurement, Head of Procurement, Head of research/strategy or international affairs or public procurement academics. Additionally, all participants are senior practitioners in their field of expertise. For each country, the highest representative with public procurement expertise was selected as a country representative. While this method is ensuring quality of the respondents, the high requirements consequently lead to

a small(er) target group. The questionnaire was filled in by 24 participants from 24 countries (table 6).

1. Afghanistan	2. Argentina	3. Belgium	4. Bhutan	5. Germany
6. Hungary	7. Indonesia	8. Italia	9. Japan	10. Kenya
11. Kosovo	12. Netherlands	13. Nigeria	14. Norway	15. Poland
16. Yemen	17. Scotland	18. Serbia	19. Slovenia	20. South Africa
21. Sweden	22. UK	23. US	24. Wales	

Table 6: country sample questionnaire 1

9.2 Development of the questionnaire

The questionnaire (appendix III) is based on the validated framework developed in chapters three till seven. Each (sub)category is transformed into a question and hence each question is supported by literature and/or government websites, as discussed in chapter five. The questionnaire is divided into three sections: I general information, II usage, III effectiveness. Before participants participated in the questionnaire, participants faced an introductory page. On this page, participants were informed about the voluntarily basis of this study, the confidentiality agreement, and the opportunity to quit or skip questions at any given time. The first part of the questionnaire questioned the mail address (optional), and the country of residence. The second part of the questionnaire questioned the usage of the instruments provided in the framework. All questions are ordinal, on a 5-point Likert scale. Participants were asked about the general usage of innovation instruments, the usage of the different policy categories (i.e. sticks, carrots, and sermons) and the subcategories (e.g. competence centers and supportive laws) according to the framework. The same questions were asked in the third part; however, usage was substituted by effectiveness. The questionnaire is shown in appendix III.

9.3 Data Gathering: Conducting a Qualitative Comparison Analysis (QCA)

9.3.1   Small sample size, equifinality, non-normal distribution and the configurations table as decisive characteristics for a preference towards QCA

QCA has three advantages: (1) relationships are asymmetrical, (2) equifinality and (3) causal complexity (Elliott, 2013, p.1). Equifinality indicates that to one outcome, there are multiple pathways and solutions, whereas causal complexity indicates that it is not solely about the independent effects (Elliott, 2013, p.1,2). In addition, a condition of the QCA is that it is designed for small-n datasets (Kent & Olsen, 2008, p. 7). The QCA tests also provides additional information, such as the truth table, in which frequent configurations of variables become visible. Hence, with QCA, a model such as equation I, can be tested.

$$public\ procurement\ innovation\ instruments\ effectiveness =$$
$$sticks\ effectiveness + carrots\ effectiveness + sermons\ effectiveness$$

Equation 1: general instrument effectiveness model

Due to the ordinal scale and non-normal distribution, classical tests such as the t-test, regression, factor analysis and ANOVA cannot be performed correctly on this data set. Similarly, an ordinal regression is not possible due to the violated assumption of proportional odds. Additionally, a cluster analysis can be performed to cluster the countries, however, this is not within the scope of this study. Non-parametric tests such as the Friedman, Wilcoxon-Signed Rank and Mann-Whitney U tests are optional, since all assumptions are met. However, the combination of a small sample size with a multiple testing problem might be problematic. The Bonferroni adjustment implies that corrections in the p-value are necessary due to the multiple tests in one comparison that may spur significant p-values. Hence, due to the downward adjusted p-values, the small sample size and the small hypostatized effects, these non-parametric tests might not be an optimal fit. To conduct a full analysis, both the combination of instruments (using QCA), as well as the differences between instruments (using descriptive statistics and the Friedman test) are investigated. Table 7 provides an overview of the statistical measures that can (and cannot) be used to analyze the usability and effectiveness of innovation policy instruments.

Test	Optional, why (not), *cautions*
T-test, Regression, factor analysis, ANOVA	**No.** Data is not normally distributed by definition of ordinal data
Ordinal regression	**No.** The assumption of proportional odds is violated
Structural Equation Modeling	**No.** Data is not normally distributed by definition of ordinal data
Cluster analysis	**Yes.** Clustering on countries is possible. *Not within the scope of this research*
Mann-Whitney U test	**Yes.** Ordinal, Random Sample. *Sample size & Bonferroni adjustment.*
Friedman	**Yes.** Ordinal, Random Sample. *Sample size.*
Wilcoxon Signed Ranks Test	**Yes.** Ordinal, Random Sample. *Sample size & Bonferroni adjustment*
Spearman Correlations	**Yes.** Applicable for ordinal data. *No statistical test*
Mean – SD	**Yes.** *No statistical test*
fuzzy set Qualitative Comparative Analysis (QCA)	**Yes.** Qualitative data and small sample sizes. *Only a limited number of variables per test.*

Table 7: possible tests for usage and effectiveness analysis

9.3.2 Step by step procedure of the QCA analysis

First, the Friedman test and descriptive analysis were performed using SPSS, to test for mean differences between the instruments. If the Friedman test appeared to be significant, a post hoc analysis was performed to indicate the corresponding categories that have significant mean differences. The Wilcoxon signed-rank tests functions as the post hoc analysis. After the analysis for differences within categories, the similarities—in terms of usage patterns and effective combinations—within categories are analyzed, by performing a qualitative comparison analysis.

First, the SPSS data set needed to be transferred to the FS QCA 3 program. The data was collected on a five-point Likert scale. Whereas a crisp QCA set has values of 0 and 1, zero for non-memberships and one for full membership, in a fuzzy set, data can be any variable between 0 and 1 (Ragin, 2017, p.46). A fuzzy score of 0.5 indicates that the value is indifferent, neither in nor out the set (Kent & Olsen, 2008, p.3). As a consequence, cases including this value are not taken into account in the analysis. Subsequently, running the analysis with a 0.5 value, around half of the cases would not have been taken into account. As such, the 5-point Likert scale values were transformed into 0-0,25-0,51-0,75-1 values and transferred into the FS QCA program. This indicates that "*to a moderate extent*" (x=3), is in the set perceived as used or effective. The configuration table indicates the five tests that are performed for the usage

analysis, describing the variables, measurements, measurement calibrations and the descriptive measurements (table 8). The consistency table for effectiveness can be found in appendix IV.

After the construction of the configuration table, the second step involves the construction of the truth table. The truth table is an analysis of commonly used configurations, and thus clarifies the relationships between the variables and the outcome (Grofman & Schneider, 2009, p. 663). An example of a truth table is provided in table 9 (page 37). The truth tables are especially interesting for the usage analysis, as it indicates the configuration patterns of instruments that are most used by different countries. The truth tables of the effectiveness analysis can be found in appendix V.

The heart of the effectiveness analysis is the expression of the solution formula, which constitutes the third step. The assessment of the formula is based on two main variables: consistency and coverage. Consistency *"expresses the proportion of the cases with the condition X where we also find the outcome Y, relative to all cases with X"* (Grofman & Schneider, 2009, p.665). In other words, whether X is a consistent subset of the membership outcome (Ragin, 2017, p.53). Coverage, on the other hand, indicates the percentage of the outcome that is covered through a solution (Schneider & Wagemann, 2010, p.7). Raw coverage indicates the contribution to the solution by a certain path, whereas unique coverage indicates the contribution of a certain path that exclusively explains the solution (Schneider & Wagemann, 2010, p.7).

Before running the analysis, the consistency cutoff score was set at 0.90, as consistency should be as close to 1.0 as possible, and above 0.8 at a minimum (Kent & Olsen, 2008, p.6; Ragin, 2009, p.46; Ragin, 2017, p.53). The analysis provides the least and most parsimonious model (simplest scientific explanation that fits the evidence), as well as the intermediate steps. As advised by Ragin (2009, p.203) this study takes into account the parsimonious model as well as the intermediate steps. The overall outcome is provided in a table (see table 16, page 43). The variables included in the parsimonious model are indicated as core conditions, denoted with

● if the core condition is present, and with ⊗ , if the core conditions are absent. Variables included in the intermediate model are indicated as complementary conditions, denoted with ● if the condition is present, and with ⊗ , if the condition is absent (see Ragin, 2009, p. 201-205). Additionally, the raw coverage, unique coverage and consistency are presented per solution, as well as the coverage and consistency of the complete outcome.

It is important to note that the manner of which the data is converted into the data set, the number of potential causal combinations (more variables indicate more combinations), the number of excluded configurations, and the level of consistency chosen are of influence on the outcome of the analysis (Kent & Olsen, 2008, p.9).

Out come	causal conditions	measure	fully in	mostly in	more in than out	mostly out	fully out	mean	STD	min	max
General usage	stick usage	*To what extent did you make use of the following three categories in terms of public procurement innovation policy instruments?*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.26	1.251	1	5
	carrot usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.09	0.997	1	5
	sermon usage	*Sticks (formal regulation), carrots (materialistic resources), sermons (knowledge transfer)*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.5	1.18	1	5
Sticks usage	restrictive laws usage	*To what extent did you make use of formalized regulation instruments in the category of "sticks" to promote innovation? restrictive laws, supportive laws, targets, certification*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.38	1.209	1	5
	supportive laws usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.83	1.129	1	4
	targets usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.79	1.179	1	5
	certification usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.61	1.234	1	5
Carrot usage	R&D funding usage	*To what extent did you make use of the following subcategories in the category of "carrots" to promote innovation? R&D funding, Expertise Funding, aftercare Funding (e.g. marketing, pilots), a specified government budget for unspecified financial instruments*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.51	1.103	1	5
	expertise funding usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.71	1.083	1	5
	after care usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.54	1.179	1	5
	non-specified usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.25	1.26	1	5

Outcome	causal conditions	measure	fully in — A very large extent (5)	mostly in — A large extent (4)	more in than out — A moderate extent (3)	mostly out — A small extent (2)	fully out — Not at all (1)	mean	STD	min	max
R&D funding usage	SBIR	*To what extent did you make use of R&D instruments to promote innovation? SBIR, Innovation Challenges, PCP, Co-Funding, Public Procurement Innovation Awards, Insurance, Catalogues, Contracts, Unsolicited Proposals*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.17	1.029	1	4
	Innovation Challenges		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.35	1.152	1	4
	PCP		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.5	1.102	1	4
	Co funding		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.42	1.06	1	4
	Awards		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.61	1.305	1	5
	Insurance		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	1.78	0.998	1	4
	Catalogues		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.26	1.137	1	4
	Contracts		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3	1.279	1	5
	Unsolicited proposals		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.14	0.964	1	4
Sermon usage	Competence center usage	To what extent did you make use of instruments in the category of "sermons" to promote innovation? competence centers / innovation platforms, newsletters and/or events, consultancy and/or training, guides/manuals/best practices, government declarations and/or action plans	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.77	1.541	1	5
	Newsletters & events usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.96	1.147	1	5
	Consultancy & training usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.21	1.285	1	5
	Guides usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.29	1.334	1	5
	Government declarations usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.83	1.39	1	5

Table 8: consistency table fs QCA instrument usage

10. QCA Results: Assessing usage and effectiveness of innovation instruments

10.1   Results of usage analysis, preformed with QCA

10.1.1 Using instruments from the stick, carrot and sermon category is the most frequent pattern for general instrument usage

Table 8 notes that sermons appear to be used the most. However, all three categories, and overall usage of instruments seem to have an average perceived usage of a moderate extent (x=3). The differences among the three categories is statistically tested using the non-parametric Friedman test. Concluding that there is not a statistically significant difference within the usage of sticks, carrots, sermon categorization, $\chi^2(2) = 4.066$, $p = 0.131$. The truth table of general usage, explained by sticks, carrots and sermon usage, allows for an analysis of commonly used configurations (table 9). The combinations with no configurations are excluded from the table. A value of 0 indicates that the value was below 0.5 (e.g. to no extent and to a small extent in the questionnaire scaling), whereas a value of 1 indicates that the value was above 0.5 (e.g. a moderate, large and very large extent in the questionnaire scaling). The table indicates that most of the times (13 out of 24), a country uses a combination of all three instrument categorizations (i.e. both sticks, carrots and sermons). The second most frequent utilized combination is the combination of only sermons and carrots instruments (i.e. as is the case for Argentina, Netherlands, Belgium and Slovenia).

Sticks	Carrot	Sermon	General	number	Cases	Consistency
1	1	1	1	13	Bhutan, Afghanistan, Nigeria, Norway, Italy, South Africa, Kosovo, Yemen, USA, Germany, Serbia, Japan, Hungary	0.947
0	1	1	1	4	Argentina, Netherlands, Belgium, Slovenia	0.96
0	0	0	0	2	Kenya, Wales,	0.74
1	0	1	1	3	Indonesia, Sweden	1
1	0	0	1	1	Poland	0.91
1	1	0	1	1	Scotland	1

Table 9: fs QCA analysis, general usage truth table

10.1.2 A combination of all subcategories of stick instruments is most frequently used by countries

All four subcategories of the category sticks have an average perceived usage between 'little' and 'moderate' (table 8). Supportive sticks have the highest perceived usage, whereas

restrictive laws have a slightly lower perceived usage, which is the lowest of this category. The differences among the four subcategories' means is statistically tested using the non-parametric Friedman test. There is a not a statically significant mean difference within the usage of the sticks categorization (restrictive, supportive, targets and certification), $\chi^2(3) = 6.485$, $p = 0.090$. The truth table of perceived sticks usage, explained by restrictive (restraining), supportive, targets and certification, allows for an analysis of commonly used configurations (table 10). The table indicates that most of the times (9 out of 24), a country uses of all four sub-categorizaties. Interestingly, the second most frequent combination is the combination of no perceived usage of any of the instruments (i.e. as is the case for Kosovo, Scotland, Kenya, Wales and Slovenia).

Restrictive laws	Supportive laws	Targets	Certifi-cation	Sticks	number	Cases	Consistency
1	1	1	1	1	9	Bhutan, Afghanistan, Nigeria, Norway, South Africa, Yemen, USA, Serbia, Japan	1
0	0	0	0	0	5	Kosovo, Scotland, Kenya, Wales, Slovenia	0.6
0	1	1	1	1	2	Sweden, Hungary	1
1	1	1	0	1	2	Indonesia, Italy	1
0	0	0	1	1	1	Germany	1
0	1	0	0	1	1	Argentina	0.95
1	1	0	0	1	1	Poland	1
1	0	1	0	1	1	Netherlands	0.9

Table 10: fs QCA analysis, sticks usage truth table

10.1.3 No usage of any materialistic instruments is the reality for seven countries

All four subcategories of the category carrots have an average perceived usage between 'little' and 'moderate' (table 8). Expertise funding has the highest perceived usage within this category, whereas unspecified funding has the lowest. The differences among the four subcategories' means is statistically tested using the non-parametric Friedman test. There is no statistically significant mean difference within the usage of the sermons categorization (R&D funding, Expertise funding, after care funding and a non-specified government budget), $\chi^2(3) =$

2.854, $p = 0.415$.The truth table of perceived carrot usage, explained by R&D funding, expertise funding, aftercare funding and unspecified funding allows for an analysis of commonly used configurations (table 11). The table indicates that most of the times (7 out of 24), a country does not use any of the four sub-categories. The second most frequent combination is the combination of the perceived usage of all the instruments, which is the case for five countries.

R&D funding	Expertise funding	Aftercare funding	Unspecified funding	Carrot	number	Cases	Consistency
0	0	0	0	0	7	Italy, Indonesia, Kosovo, Yemen, Sweden, Kenya, Wales	0.64
1	1	1	1	1	5	Norway, South Africa, USA, Japan, Hungary	1
0	1	1	0	1	3	Netherlands, Serbia, Slovenia	0.95
0	1	0	0	1	2	Nigeria, Poland	0.95
1	0	0	0	1	1	Argentina	1

Table 11: fs QCA analysis, carrot usage truth table

10.1.3.1 Many countries use unique combinations of R&D funding instruments

The instruments of the subcategory R&D funding have an average perceived usage between 'none at all' and 'moderate' (table 8). The instrument 'contracts' has the highest perceived usage (3.00), whereas insurance (1.78) has the lowest perceived usage. The differences among the instruments are statistically tested using the non-parametric Friedman test. There is no statistically significant difference within the perceived usage of the R&D funding instruments within the 'carrots' categorization, $\chi^2(8) = 20.130$, $p = 0.010$. The truth table of perceived usage of R&D funding instruments, allows for an analysis of commonly used configurations (table 12). The table indicates that most countries use unique configurations (14 times). The most frequent combination is a usage combination of none of the instruments (4 cases).

SBIR	Challenges	PCP	Co-funding	Awards	Insurance	Catalogues	Contracts	Solicited Proposals	R&D funding	number	Cases	Consistency
0	0	0	0	0	0	0	0	0	0	4	Kenya, Wales, Poland, Yemen	0.43
1	1	1	1	1	0	1	1	0	1	2	Norway, Hungary	1
1	1	1	1	1	1	1	1	1	1	2	USA, South Africa	1
0	0	0	1	1	0	0	0	0	0	1	Netherlands	0.89
1	1	1	1	1	1	0	0	0	1	1	Japan	1
1	0	0	0	1	0	1	1	0	0	1	Germany	0.89
1	0	1	0	1	0	0	1	1	1	1	Afghanistan	1
0	1	1	0	1	0	1	1	1	1	1	Kosovo	0.9
0	0	0	1	1	1	1	1	1	0	1	Serbia	0.88
0	0	1	1	0	0	0	0	0	1	1	Nigeria	0.91
1	1	1	1	0	0	0	0	0	1	1	Bhutan	0.91
0	1	0	1	0	0	0	1	0	1	1	Belgium	1
0	0	0	0	0	0	0	1	1	0	1	Slovenia	0.77
0	0	1	0	0	0	0	1	1	0	1	Sweden	0.87

Table 12: fs QCA analysis, R&D funding usage truth table

10.1.4 Many countries use all categorized informative instruments to at least a moderate extent

The subcategories within the sermon category have a 'moderate' perceived usage on average (table 8). The subcategory 'guides, best practices, and manuals' has the highest perceived usage (3.29), whereas competence centers and innovation platforms (2.77) has the lowest perceived usage. The differences among the subcategories is statistically tested using the non-parametric Friedman test. There is no statistically significant difference within the perceived usage of the sermon categorization (competence centers, newsletters and/or events, consultancy and/or training, guides/manuals/ best practices, government declarations/action plans), $\chi^2(4) = 7.863$, $p = 0.097$. The truth table of perceived sermon usage allows for an analysis of commonly used configurations (table 13). The table indicates that most countries use a configuration of all the subcategories of sermons (i.e. competence centers + newsletters and events + consultancy and training + guides +government declarations) (9 times). These countries

include Afghanistan, Norway, Netherlands, Germany, South Africa, USA, Nigeria, Italy and Yemen.

Competence centers & Innovation platforms	Newsletters & Events	Consultancy & Training	Guides & Manuals	Government declarations and action plans	Sermon	Number	Cases	Consistency
1	1	1	1	1	1	9	Afghanistan, Norway, Netherlands, Germany, South Africa, USA, Nigeria, Italy, Yemen	1
0	0	0	0	0	0	3	Belgium, Wales, Kenya	0.7
1	1	1	1	0	1	2	Japan, Hungary	1
0	1	1	1	1	1	2	Bhutan, Kosovo	1
0	1	0	0	0	1	1	Sweden	1
0	1	1	0	0	1	1	Slovenia	1
0	0	1	1	0	1	1	Serbia	1
0	0	0	0	1	1	1	Indonesia	1
0	1	1	0	1	1	1	Argentina	1
0	0	1	0	0	0	1	Poland	0.87

Table 13: fs QCA analysis, sermon usage truth table

10.2 Results of usage analysis, preformed with QCA

10.2.1 General instrument effectiveness is a core-function of carrot or sermon effectiveness

Carrots and Sermons appear to be most effective, based on descriptive statistics (appendix IV). All three categories, and the overall effectiveness of instruments have an average of perceived effectiveness from a moderate extent to large extent (between x=3 and x=4). The differences among the three categories is statistically tested using the non-parametric Friedman test. Concluding that there is no statistically significant difference within the effectiveness of sticks, carrots, sermons categorization, $\chi^2(2) = 3.309, p = 0.191$. The truth table of general effectiveness, explained by sticks, carrots and sermon effectiveness, allows for an analysis of commonly effective configurations (appendix V). The table indicates that most of the times (17 out of 24), the country representatives perceive all three categorizations as effective.

The results of the analysis are shown in table 14. As the table shows, two different configurations consistently link to a moderate to high effectiveness of innovation policy instruments. The first configuration indicates that irrespective of sticks and sermon effectiveness, carrot effectiveness leads to overall perceived instrument effectiveness. The second pathway indicates that irrespective of carrots, sermon effectiveness leads to high perceived effectiveness of innovation instruments, along with the complementary condition that effective sticks are not present.

Solutions for overall instrument effectiveness		
	1	2
Stick effectiveness		⊗
Carrot effectiveness	●	
Sermon effectiveness		●
Raw Coverage	0.934	0.511
Unique Coverage	0.423	0
Consistency	0.904	0.912
Overall Solution Coverage	0.934	
Overall Solution Consistency	0.890	

Table 14: fs QCA analysis, general effectiveness of instruments

10.2.2 The core condition of stick effectiveness is that effective supportive laws are present

The average perceived effectiveness within sticks falls between 'little' and 'very' effective (appendix IV). As expected, intuition wise, supportive sticks have a higher perceived effectiveness compared to restrictive sticks. The differences among the four subcategories is statistically tested using the non-parametric Friedman test. There is a statically significant difference within the effectiveness of the sticks categorization (restrictive, supportive, targets and certification), $\chi^2(3) = 16.585, p = 0.001$. Afterwards, a post hoc analysis with Wilcoxon signed-rank tests was applied using the Bonferroni correction, resulting at a significance level set at $p < 0.009$ (0.005/6). Two statistically significant differences between the instruments are found after the post hoc analysis (table 15). Firstly, the perceived effectiveness of supportive laws is statistically significantly different from the perceived effectiveness of restrictive laws ($Z = -3.260, p = 0.001$). Secondly, the perceived effectiveness of targets is statistically significantly different from the perceived effectiveness of restrictive laws ($Z = -2.633, p = 0.008$).

	Mean	Significance
Supportive – Restrictive	**3.83 – 2.50**	**0.001**
Targets – Restrictive	**3.33 – 2.50**	**0.008**
Supportive – Targets	3.83 – 3.33	0.822
Supportive – Certification	3.83 – 3.00	0.083
Certification – Restrictive	3.00 – 2.50	0.035
Certification – Targets	3.00 – 3.33	0.111

Table 15: Wilcoxon signed-rank tests on sticks

The truth table of perceived sticks effectiveness, explained by (restraining) restrictive laws, supportive laws, targets and certification, allows for an analysis of commonly effective configurations (appendix V). The table indicates that half of the time (12 out of 24 cases), a country representative perceives all four categorizations (including restrictive laws) as effective. The second most frequent combination is the combination of no perceived effectiveness of restrictive laws and certification, while targets and supportive laws are perceived as effective (i.e. as is the case for Sweden, Netherlands, Slovenia, Argentina, Scotland).

The results of the QCA are shown in table 16. As the table shows, the effectiveness of sticks is based on one core-condition: that effective supportive laws are present. Consequently, three different configurations, with different complementary conditions, can lead to a perceived effectiveness of sticks. Firstly, the configuration of effective supportive laws can be complemented by the absence of effective restrictive laws and the presence of effective targets. Secondly, effective supportive laws can be complemented by target effectiveness and certification effectiveness. Lastly, effective supportive laws can be complemented by the absence of effective certification and targets, while restrictive laws are effectively present.

Solutions for stick effectiveness			
	1a	1b	1c
Restrictive laws effectiveness	⊗		●
Supportive laws effectiveness	●	●	●
Target effectiveness	●	●	⊗
Certification effectiveness		●	⊗
Raw Coverage	0.709	0.722	0.409
Unique Coverage	0.076	0.071	0.038
Consistency	0.882	0.950	1
Overall Solution Coverage	0.836		
Overall Solution Consistency	0.879		

Table 16: fs QCA analysis, effectiveness of stick instruments

10.2.3 Carrot effectiveness is primarily based on the presence of effective R&D funding

All four subcategories of the category carrots have an average perceived effectiveness between 'moderate' and 'large' (appendix IV). Expertise funding has the highest perceived effectiveness within the carrot category, slightly higher compared to least effective subcategory of carrots: the unspecified funding. The differences among the four subcategories is statistically tested using the non-parametric Friedman test. There is no statistically significant difference within the effectiveness of the sermons categorization (R&D funding, expertise funding, after care funding and a non-specified government budget), $\chi^2(3) = 3.157$, $p = 0.368$. The truth table of perceived carrot effectiveness, explained by R&D funding, expertise funding, after-care funding and unspecified funding allows for an analysis of commonly used configurations (appendix V). The table indicates that more than half of the time (14 out of 24), a country representative perceives all four categorizations as effective. The second most frequent combination is the combination of the perceived effectiveness of all the instruments except for an unspecified budget.

The solution to an effective carrot category is based on the core condition that effective R&D funding is present in the equation, as presented in table 17. Additionally, in both pathways, effective aftercare funding should be present, as a complementary condition. Besides R&D funding and aftercare funding, either an effective unspecified budget should not be present, or effective expertise funding should be present to achieve an effective carrot category.

Solutions for carrot effectiveness		
	1a	1b
R&D funding effectiveness	●	●
Expertise funding effectiveness		•
Aftercare funding effectiveness	•	•
unspecified budget funding effectiveness	⊗	
Raw Coverage	0.542	0.821
Unique Coverage	0.019	0.299
Consistency	0.937	0.978
Overall Solution Coverage	0.840	
Overall Solution Consistency	0.957	

Table 17: fs QCA analysis, effectiveness carrot instruments

10.2.3.1 Different R&D funding instruments reach statistically different perceived effectiveness levels

The instruments of the subcategory R&D have an average perceived effectiveness between 'little' and 'large' (appendix IV). The instrument 'contracts' has the highest perceived effectiveness (3.58), whereas unsolicited proposals has the lowest perceived effectiveness (2.78). The differences among the instruments are statistically tested using the non-parametric Friedman test. There is a statistically significant difference within the perceived usage of the 'R&D funding' instruments within the 'carrots' categorization, $\chi^2(8) = 22.903$, $p = 0.003$.

Afterwards, a post hoc analysis with Wilcoxon signed-rank tests was applied. When using the Bonferroni correction, the significance level should be set at $p < 0.001$ (0.005/36). However, due to the sample size and the small effect size, this significance level is statistically impossible. Hence an error-term of one percent is taken as a p-value. This results in six significant differences between the instruments after the post hoc analysis (table 18 & 19). Firstly, the perceived effectiveness of SBIR is statistically significantly different from the perceived effectiveness of co-funding ($Z = -2.725$, $p = 0.006$). Secondly, the perceived effectiveness of challenges is statistically significantly different from the perceived effectiveness of unsolicited proposals ($Z = -2.648$, $p = 0.008$). Thirdly, the perceived effectiveness of PCP is statistically significantly different from the perceived effectiveness of co-funding ($Z = -3.071$, $p = 0.002$). Fourthly, the perceived effectiveness of co-funding is statistically significantly different from the perceived effectiveness of unsolicited proposals ($Z = -2.887$, $p = 0.004$). Fifthly, the perceived effectiveness of awards is statistically significantly different from the perceived effectiveness of unsolicited proposals ($Z = -2.949$, $p = 0.003$). Lastly, the perceived effectiveness of contracts is statistically significantly different from the perceived effectiveness unsolicited proposals ($Z = -2.682$, $p = 0.007$).

	Mean	Significance
SBIR- Co-funding	**2.87 – 3.48**	**0.006**
Challenges- Unsolicited P.	**3.36 – 2.74**	**0.008**
PCP- Co-funding	**2.91 – 3.48**	**0.002**
Co-funding – Unsolicited P.	**3.48 – 2.74**	**0.004**
Awards – Unsolicited P.	**3.36 – 2.74**	**0.003**
Contracts- Unsolicited P.	**3.58 – 2.74**	**0.007**

Table 18: Wilcoxon signed-rank tests on R&D funding

	SBIR	Chal	PCP	Cof	Aw	Insur	Cata	Contr	Unsol
SBIR		0.017	0.564	**0.006**	0.70	0.793	0.766	0.011	0.713
Chal			0.020	0.132	0.832	0.033	0.160	0.498	**0.008**
PCP				**0.002**	0.162	0.508	0.905	0.026	0.462
Cof.					0.289	0.052	0.099	0.928	**0.004**
Aw						0.016	0.205	0.519	**0.003**
Insur							0.377	0.015	1.000
Cata								0.023	0.480
Contr									**0.007**
Unsol									

Table 19: Wilcoxon signed-rank tests on R&D funding (2)

10.2.4 To achieve sermon effectiveness, six different core solutions are optional

The subcategories within the sermon category have a 'moderate' to 'large' perceived effectiveness on average (appendix IV). The subcategory 'consultancy and training' has the highest perceived effectiveness (3.63), whereas newsletters and events (3.17) has the lowest perceived effectiveness. The differences among the subcategories is statistically tested using the non-parametric Friedman test. There is no statistically significant difference within the perceived effectiveness of the sermon categorization (competence centers, newsletters and/or events, consultancy and/or training, guides/manuals/ best practices, government declarations/action plans), $\chi^2(4) = 5.487, p = 0.241$. The truth table of perceived sermon effectiveness allows for an analysis of commonly effective configurations (appendix V). The table indicates that most countries find a configuration of all the subcategories of sermons (i.e. competence centers + newsletters and events + consultancy and training + guides + government declarations) is most effective (12 times).

The results of the analysis are shown in table 20. As the table shows, six different configurations consistently link to a moderate to high effectiveness of the sermon category. The six different pathways have different core conditions. The first core condition of the first solution includes the absence of effective consultancy and training. Whereas the core conditions of the fourth pathway include the presence of both effective competence centers and effective guides. Similarly, the fifth solution includes the presence of both effective newsletters & events and

guides & manuals. The solution with the highest coverage (indicating that these solution terms explain and cover the outcome as a whole to the largest extent) is the pathway were effective guides are a core condition, and effective newsletters & events or competence centers too. In this solution, the presence of effective consultancy and either competence centers or newsletters, are the complementary conditions.

Solution sermon effectiveness						
	1	2	3	4	5	6
Competence center effectiveness	⊗	⊗	⊗	●	•	●
Newsletters & Events effectiveness	•	⊗	⊗	•	●	⊗
Consultancy & Training effectiveness	⊗	⊗	⊗	•	•	•
Guides & Manuals effectiveness	•	⊗	⊗	●	●	
Government declarations effectiveness	•	•	●			●
Raw Coverage	0.299	0.297	0.297	0.652	0.652	0.496
Unique Coverage	0.017	0	0	0.208	0.208	0.020
Consistency	1	0.945	0.945	0.950	0.950	0.940
Overall Solution Coverage	0.721					
Overall Solution Consistency	0.933					

Table 20: fs QCA analysis, effectiveness sermon instruments

11. Step 4 – Validation of the usage and effectiveness analysis

The last step in this research is to validate the results of the usage and effectiveness analysis (figure 10). The previously performed analysis was done using one country representative with a high procurement function (i.e. government CPO) to represent the country. Hence, the analysis was performed with a small sample size. Additionally, it qualified more as a top-down approach. To validate the results, a bottom-up approach is used, targeting procurement academics and practitioners to through the network of the international research study, and trough public procurement organizations. The questionnaire used was designed and distributed by the international research study committee.
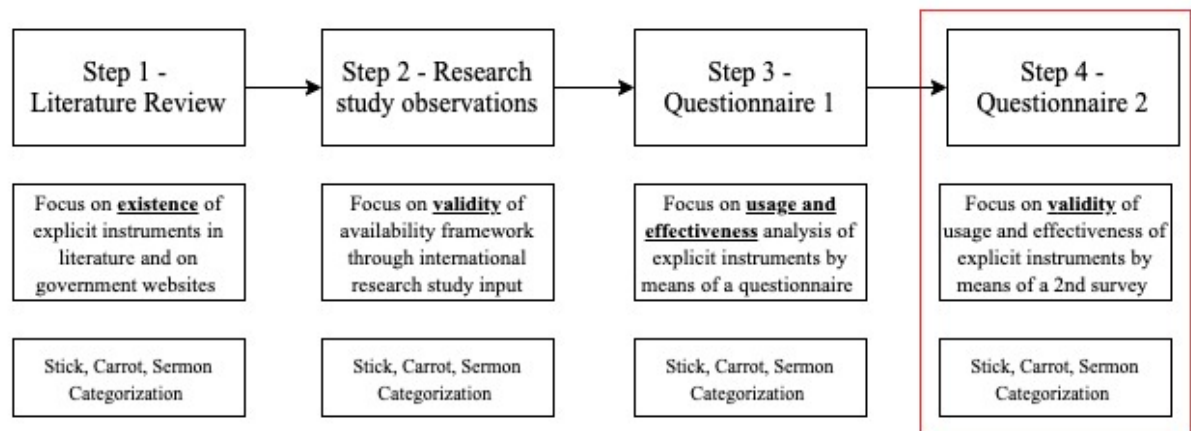
Figure 10: the research approach

12. Methodology: Validating the usage and effectiveness analysis

12.1   Sampling: Analysis is based external questionnaire

In total, 80 individuals participated in the external questionnaire, originating from 21 countries, which are identical to the countries of questionnaire 1 (with the exception of Yemen, Kenya and Bhutan). The questionnaire was distributed online within the International Research Study network by the International Research Study committee. The target population included public organizations such as NIGP, NEVI, CIPS, but also academics and senior practitioners within public procurement. Specifically targeting the international research study network ensures that participants are involved within public procurement. This is a continuously growing network that is steadily built up from the 21st century onwards. Exactly half of the participants are from the United States, whereas fifteen countries only had one or two participants, indicating that less than 30 percent of the sampled countries make up for 75 percent of the sample size. These countries include Argentina, Canada, Italy, Netherlands, and United States.

12.2   Questionnaire design and development

The development of the questionnaire was done externally, by the international research study committee for their own research on public procurement of innovations. Only the questions applicable for this study were used for verification purposes. The external questionnaire is divided into three sections (1) general information, (2) innovation project, (3) government innovation policy. The complete questionnaire can be found in appendix VI. Not all questions are applicable to this study; only five questions are utilized for the usage and effectiveness verification. The questions used for this research are indicated in table 21 and

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highlighted in appendix VI. Whereas the questionnaire 1 of this study aims to provide an overview of the general usage and effectiveness, this external data source aims to provide an overview of how often innovation policy instruments are used in different settings (institution, government, and within a project), and how effective instruments are within a specific project. Before participation in the questionnaires, participants faced an introductory page. On this page, participants were informed about the voluntarily basis of this study, the confidentiality agreement, and the opportunity to quit or skip questions at any given time.

Theme	Questions
Usage	**B8:** *Please indicate to what extent the following instruments were used to support this particular innovation project* **B13:** *To the best of your knowledge, please rate to what extent the following instruments are used by your institution to stimulate innovation through PP* **C3:** *To the best of your knowledge, please rate to what extent you are aware of the following instruments being used by your government to stimulate innovation directly with business, economy and society*
Effectiveness	**B9:** *In your view, please rate what your institution achieved operationally through this innovation project* **B10:** *In your view, please rate how much the innovation project contributed to strategic and policy objectives of your institution* *B9 and B10 interact with **B8** (i.e. the effectiveness of the project is irrelevant for this study if instruments are not used)

Table 21: Questions utilized from external questionnaire

12.3   Data gathering: Conducting usage and effectiveness analysis using non-parametric tests

Table 22 provides an overview of the statistical measures that can be used to analyze the usability and effectiveness of innovation policy instruments using the external questionnaire. Due to the ordinal scale and non-normal distribution, classical tests such as the t-test, regression, factor analysis and ANOVA cannot be performed correctly. Similarly, an ordinal regression is not possible due to the violated assumption of proportional odds. The Qualitative Comparative Analysis (QCA) is only built for small data sets with limited variables, which does not make it

a suitable test. Non-parametric tests such as the Friedman, Wilcoxon-Signed Rank and Mann-Whitney U tests are optional, since all assumptions are met. Due to the increased sample size (n=80), these tests are a better fit here compared to the first questionnaire of the study. Nevertheless, the multi-comparison problem occurs, which indicates the obligation of the Bonferroni adjustment. The Bonferroni adjustment implies that corrections in the p-value are necessary due to the multiple tests in one comparison that may spur significant p-values. Therefore, this non-parametric test is only utilized for the effectiveness analysis, as the effectiveness analysis is in need of an interaction variable (i.e. the effectiveness of the project is irrelevant for this study if instruments are not used). The usage analysis will be done using descriptive tables.

Test	Optional?	Why (not)	Cautions
T-test, Regression, factor analysis, ANOVA	No	Data is not normally distributed by definition of ordinal data	
Ordinal regression	No	The assumption of proportional odds is violated	
Structural Equation Modeling	No	Data is not normally distributed by definition of ordinal data	
fuzzy set Qualitative Comparative Analysis (QCA)	No	Only a few variables per set, only for small sample sizes	
Cluster analysis	Maybe	Clustering on countries is possible	Not within the scope of this research
Mann-Whitney U test	Yes, in some cases	Ordinal, Random Sample *Independence of observations**	Sample size & Bonferroni adjustment *Usage of Dummy variable
Friedman	Yes	Ordinal, Random Sample	Sample size
Wilcoxon Signed Ranks Test	Yes	Ordinal, Random Sample	Sample size & Bonferroni adjustment
Spearman Correlations	Yes	Applicable for ordinal data	-
Mean – SD	Yes	No statistical test	-

Table 22: possible tests for usage and effectiveness analysis

Questions B8, B13 and C3 are used for the 'usage' analysis (appendix VI). All three questions (B8, B13, C3) include the same thirteen variables (instruments), indicated in the left column of table 23. All thirteen variables (instruments) are coded into three categories (sticks, carrots, sermons, table 23), where usability can be compared on a 5-point Likert scale (1: not at all, 5: to a very large extent). The coding of categories is done deductively by the researcher and is triangulated by two other researchers to ensure validity (Burnhard (1991, p.462). Afterwards, the average of the three questions are combined to provide a categorized overview of the usability of public procurement innovation policy instruments.

Categorization innovation policy instruments from question B8, B13, C3 (appendix VI)	
Subsidies for innovative start-up companies	Carrot
Grants for training and investment in companies	Carrot
Innovation open days for suppliers	Sermon
Prompt payment to small businesses	Stick
Prizes and awards for innovation	Carrot
Advertising and media to promote innovation	Sermon
Public procurement website or online help for innovation	Sermon
Matchmaking for innovation partnerships between suppliers	Sermon
Preferential treatment for innovative suppliers	Stick
Reduced administration in bidding for innovation focused contracts	Stick
Use of offsets to promote innovation	Carrot
Allocation of selected spend categories for innovative products and services	Sermon
Flat fees for innovation contracts	Carrot

Table 23: categorization of instruments in question B8, B13, C3

The non-parametric analysis for effectiveness, is performed as follows; to measure the effectiveness of the public procurement innovation policy instruments within the external questionnaire, a dummy variable was computed out of all thirteen innovation project instruments (question B8). Used to a little extent ($x=2$) combined with not used at all ($x=1$) are categorized into 0—indicating that the instrument was not used. From a moderate usage to very large usage ($x=3,4,5$) was categorized as 1—indicating that the instrument was used. Using the Man-Whitney U test, the non-paramedic equivalent of a t-test, the dummy variables were measured against the operational achievement (question B9) and the strategic achievement (question B10) of the innovation project. The Man-Whitney U test was done for each instrument, resulting in a total of thirteen tests. Since the multiple comparison testing problem occurs, the Bonferroni correction was used to alter the P value. The altered P value is 0.004 (0.05/13).

13. Results: Validating the usage and effectiveness of innovation instruments

13.1   Validating the results of the usage analysis

Within the three different settings (an innovation project, an institution and by the government), a similar image appears: most tools are underused. More specifically, 48 percent of the instruments is not used at all. Although, still underused, the most used instruments are website, advertising, and prompt payment in all three the scenarios, which are used to a moderate extent (figure 11). Categorizing the instruments according to the stick, carrot and sermon categorization (see table 23), provides an overview of the usage of the different categories. Three main patterns appear (figure 12). Firstly, within the government more instruments seemed to be used (x>1) compared with the other two scenarios, institution and the project. Secondly, the average usage (x>1) of a carrot instrument is lower (45%) compared to the sticks and sermons methods (60%). Most importantly however, on average 45% of all the public procurement innovation policy instruments tools questioned in this survey are not used at all.
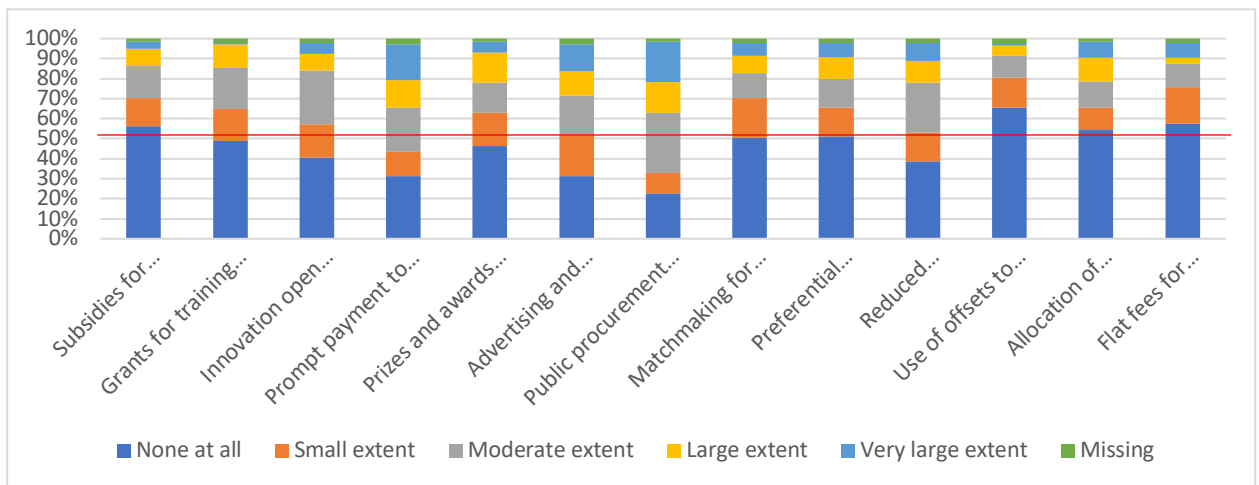

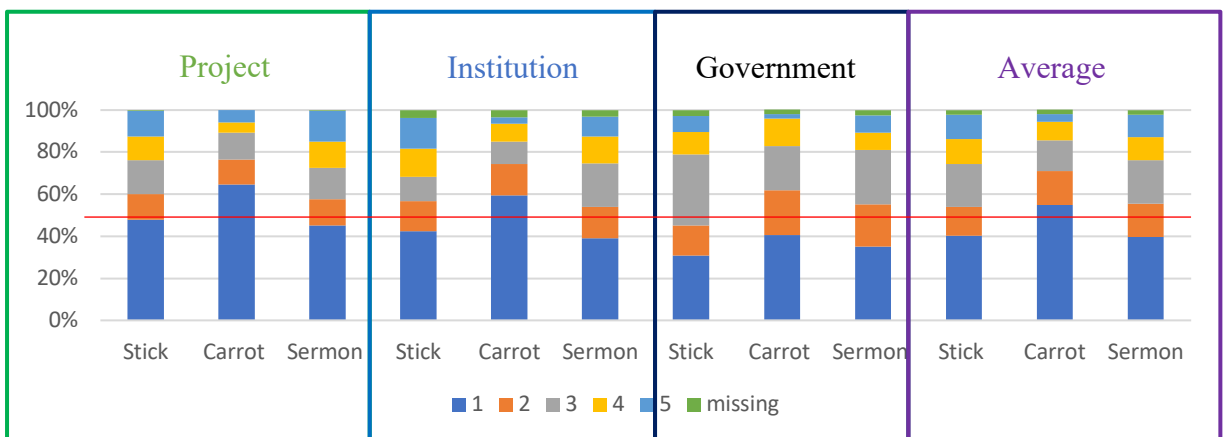*Figure 11: usage of instrument tools (validation analysis)*

Figure 12: patterns in sermon, sticks and carrot usage (validation analysis)

13.2   Validating the results of the effectiveness analysis

Table 24 provides an overview of all instruments that have a statistically significant effect. Out of thirteen instruments, eight had statistically significant effects on at least one variable of operational or strategic achievement, whereas five instruments did not. These five instruments include: (1) grants for training and investing in companies, (2) innovation open days for suppliers, (3) public procurement website, (4) preferential treatment for innovative suppliers, (5) use of offsets to promote innovation. These five instruments belong to different categories (i.e. carrots, sticks, and sermons). Hence, no pattern of ineffectiveness is apparent within the categories. Interestingly, one of the two instruments that is used the most by participants – websites—does not have any operational or strategic effect.

Similar to the non-usage of instruments, not all operational effects were reached with the thirteen instruments. Within the operational achievement, none of the instruments had a statistically significant effect on 'improving environmental sustainability' or 'reduction of supplier risk' (table 25). Within the strategic achievement, none of the instruments had a statistically significant effect on 'effective spending of budget', 'promotion of environment and sustainability', or 'collaboration with national and international bodies'. Table 25 provides an overview of the effectiveness of the instruments per category, indicating that sermons are the least effective, whereas sticks are the most effective. However, the differences are small. More generally, the effects with statistical significance are relatively low, as of the 208 possible effects, only 8.65% is statistically significant. The most effective instrument is 'prompt business payment' (five statistically significant effects), whilst 'prizes and awards' (four statistically significant effects) can also be considered effective.

Instrument	Statistically Significant effect	Sign.	Mean rank dummy 0	Mean rank dummy 1
Subsidies	B9. Improvement in satisfaction of end user needs	0.001	35.32 (61)	54.50 (17)
Subsidies	B10. Stimulation of innovation	0.003	36.06 (62)	54.35 (17)
Prompt Payment	B9. Improvement in the quality of the procurement process for the innovative good/service	0.000	28.30 (37)	48.18 (39)
Prompt Payment	B9. Increase of transparency of the process in which the goods	0.000	28.30 (37)	48.18 (39)
Prompt Payment	B9. Improvement in the competences of actors involved in the procurement process	0.001	29.99 (37)	41.68 (39)
Prompt Payment	B10. Growth of local economy and employment	0.003	32.115 (39)	46.85 (39)
Prompt Payment	B10. Support small medium enterprises	0.001	31.60 (39)	47.40 (39)
Prize & Awards	B9. Improvement in the quality of the procurement process for the innovative good/service	0.001	32.18 (44)	48.09 (33)
Prize & Awards	Improvement in the competences of actors involved in the procurement process	0.000	30.72 (44)	50.05 (33)
Prize & Awards	Stimulation of innovation	0.000	32.00 (46)	51.15 (33)
Prize & Awards	Creation of intellectual capital	0.000	30.93 (46)	52.64 (33)
Advertising	Improvement in the satisfaction of end user needs	0.001	31.04 (41)	47.24 (35)
Advertising	Stimulation of innovation	0.000	30.77 (41)	48.38 (36)
Matchmaking	Increase of transparency of the process in which the good service has been included	0.000	33.15 (55)	53.64 (22)
Matchmaking	Stimulation of innovation	0.001	34.64 (56)	53.04 (23)
Reduced administration	Simplification of the procurement process in which the good services has been included	0.002	32.40 (44)	47.80 (33)
Allocation spend categories	Reduction of the costs of the procurement process	0.002	34.24 (53)	50.66 (25)
Flat fees	Increase of transparency of the process in which the good service has been included	0.001	34.50 (59)	53.75 (18)
Flat fees	Stimulation of innovation	0.000	35.14 (61)	56.47 (18)

Table 24: statistically significant effects of usage of innovation policy instruments on strategic and operational effectiveness within an innovation project

	Stick	Carrot	Sermon	Total
B9. Improvement in the quality of the procurement process for the innovative good/service	D	E		**2**
B9. Reduction of the costs of the procurement process			L	**1**
B9. Improvement in the satisfaction of end user needs		A	F	**2**
B9. Simplification of the procurement process in which the good/service has been included	J			**1**
B9. Increase of transparency of the process in which the good/service has been included	D		H	**2**
B9. Improvement of the environmental sustainability				**0**
B9. Reduction of supplier risk in the procurement process				**0**
B9. Improvement in the competences of actors involved in the procurement process	D	E		**2**
				(10)
B10. Efficient and effective use of spending budget				**0**
B10. Promotion of environmental sustainability (e.g. reduction of pollution, environment preservation)				**0**
B10. Promotion of social sustainability (e.g. support to minorities, welfare of citizens)				**0**
B10. Growth of local economy and employment creation	D			**1**
B10. Support to small-medium enterprises	D			**1**
B10. Collaboration with national and international bodies				**0**
B10. Stimulation of innovation		A, E, M	F, H	**5**
B10. Creation of intellectual capital		E		**1**
Total	5xD, 1xJ, 0xI **(6x)** **(=8.33)**	2xA, 0xB,4xE, 0xK, 1xM **(7x)**	0xC, 2xF, 2xH, 1xL **(5x)**	**(8)** **18**

Table 25: categorized overview of statistically significant effects of usage of innovation policy instruments on strategic and operational effectiveness within an innovation project

14. Discussion: effectively using public procurement to increase innovation

14.1 Managerial implications: A blueprint for implementation of public procurement innovation instruments combinations

Step 1. The framework provides a snapshot of the available demand-side instruments within public procurement for innovation (figure 7, page 26). This framework can be used by practitioners to spot gaps and opportunities within the current available innovation instruments of a government or public organisation. Additionally, examples of interesting subcategories can be found in chapter five.

Step 2. The frequency table on page 27 (table 4), allows for comparison between own government or organizations' instruments and other countries. It for example, indicates that on average, twice as many 'knowledge transfer' instruments (sermons) are available compared to materialistic and regulative instruments (carrots and sticks). This provides practitioners with insights in how an average portfolio of public procurement innovation policy instruments might look like.

Step 3. The patterns in the usage analysis indicate that most countries usage many different instruments from different subcategories per category. The configurations in equation two, are the usage patterns that were most frequently found (i.e. available in the most countries).

$$(\mathbf{1})\ \textit{general instruments usage pattern}$$
$$= materialistic + regulative + informative\ instruments$$

$$(\mathbf{2})\ \textit{regulative instruments usage pattern}$$
$$= restrictive\ laws + supportive\ laws + targets + certification$$

$$(\mathbf{3})\ \textit{materialistic instruments usage pattern}$$
$$= R\&D\ funding + expertise\ funding + aftercare\ funding$$
$$+ unspecified\ budgets\ funding$$

$$(\mathbf{4})\ \textit{R\&D funding instruments usage pattern}$$
$$= unique\ combinations\ per\ country$$

$$(\mathbf{5})\ \textit{informative instruments usage pattern}$$
$$= competence\ centers\ \&\ information\ platforms$$
$$+ newsletters\ \&\ events + consultancy\ \&\ training + gguides\ \&\ manuals$$
$$+\ \ overnment\ declarations\ \&\ action\ plans$$

Equation 2: most frequently found instrument usage patterns, per category

Additionally, the usage analysis indicated discrepancies that one should be aware of. First of all, the standard deviation of the usage variables was on average higher compared to the standard deviation of effectiveness variables. This indicates that respondents are more unanimous about which instruments are effective, compared to which instruments are used. Consequently, one should focus on the instruments that are perceived as more effective instead of more used (i.e. one should be aware that there is a difference). On a similar note, the means of the effectiveness of instruments is also higher compared to the means of the usage of instruments. This indicates that there is still an opportunity to increase the usage towards the effectiveness levels. Lastly, there is a discrepancy between the indicated usage in the first and second questionnaire. Whereas the first questionnaire was solely filled in by highly ranked procurement experts, the second questionnaire was distributed irrespectively of the hierarchy. This indicates that there is discrepancy between the usage on top level and second-level usage. Which calls for an increase in awareness of in lower parts of the organizational hierarchy or structure.

Step 4. Figure 13 indicates a simplified blueprint to choose the right instrument categorizations to achieve the highest effectiveness of public procurement innovation policy instruments. First of all, materialistic (carrots) and knowledge transfer (sermons) instruments are preferred over the regulative instruments (sticks). Secondly, within the carrot categorization, R&D funding is preferred over the other sub-categories to achieve the highest effectiveness. However, expertise funding and after care funding are favourable complements to R&D funding. When implementing the sticks categorization, supportive laws are preferable. Within sermons, many combinations can lead to an effective knowledge transfer, however, the presence of government declarations is the only categorization that always leads to high effectiveness. Lastly, some instruments are perceived as significantly more effective compared to others. It is advised to choose co-funding over SBIR or pre-commercial procurement, and co-funding, awards, challenges, and contracts over unsolicited proposals. Similarly, supportive laws and targets should be chosen before the choosing for restrictive regulation.

Additionally, based on the validation analysis, the following instruments should not be preferred in terms of effectiveness: (1) grants for training and investing in companies, (2) innovation open days for suppliers, (3) public procurement website, (4) preferential treatment

for innovative suppliers, (5) use of offsets to promote innovation. Whereas the following two instruments are favorable: prompt business payment and prizes & awards.
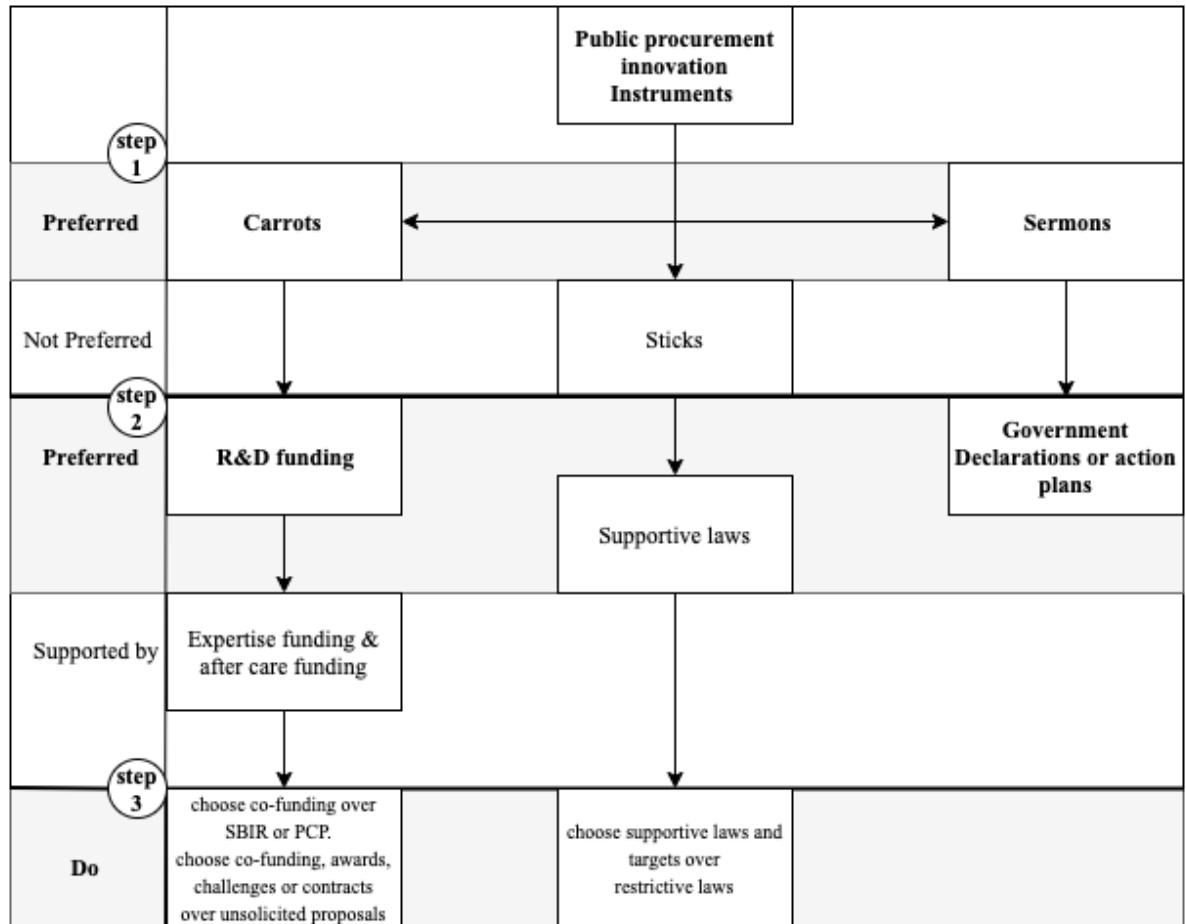

Figure 13: blueprint for choosing effective innovation policy instruments

14.2 Contribution to literature: instrument categorization and frequency identification

This paper contributes to literature in several ways. First, while opportunities that lie within procurement of innovations are frequently studied, the public procurement innovation policy instruments are not. To this day, no framework of the availability of public procurement innovation policy instruments is specifically provided, as the focus mostly lies on domestic case-studies such as Audretsch (2003), Choi, Lee, & Lee (2014), Li (2011), Rammer (2011) and Zaparucha & Muths (2011). Hence, this newly structured framework, based on the Vedung categorization, provides an overview of the availability of different innovation instruments that was not previously existent within the public procurement literature. Secondly, it responds to

the urge of Edler and Georghiou (2007, p. 961), who argue that literature on innovation policies should take demand more into the focus of policy making. Thirdly, besides the focus on the existence of policy instruments, this research provides an overview of how often certain instruments are available. Whereas existent literature focuses on case studies, which mention singular instruments, it was unknown if these instruments were present elsewhere. This study, for example, indicates that innovation instruments linked to the transfer of knowledge, are more frequently available compared to materialistic and regulative innovation instruments.

On top of that, while the potential of strategic procurement and procurement of innovation is recognized, the benefit of the public procurement innovation policies is not equally recognized (OECD, 2017a, p.42; Magina, 2019, p.4-6). Whereas policies are in place, measurement systems are not, making the benefits of such policies ambiguous. By analyzing senior practitioners' opinions about usage and effectiveness of public procurement innovation policy instruments, this research minimized the gap between potential and actual perceived benefits. This research, for example, argues that when materialistic innovation instruments are considered to be used, R&D funding should be the first category to be considered.

15. Limitations and Future research

The limitations to this study can be opportunities for future research. Firstly, this research was conducted using one public procurement expert as a representative for one country, resulting in a sample size of 24 participants and 24 countries. A sample size of 24 samples is defined as small. The sample size influences the explanatory power of the results as well as the significance levels, which ultimately affect the outcome. If a larger sample size would have been taken, results currently perceived as insignificant could have been perceived as significant. For example, according to the G*Power application, with a p-value of 0.05, a power of 0.8 and assuming a small effect size of 0.3, the required sample size is 94 respondents for the Wilcoxon signed-rank test, and 304 for the Wilcoxon Mann Whitney U test. Hence, for the sample size to be appropriate for the previously tests, the sample size should be increased by four and thirteen times, respectively. Additionally, based on Central Limit Theorem, the means approach a normal distribution as the sample size get larger. Hence, an increase in the sample size increases the changes on a normal distribution. Due to the latter, other parametric tests could be used that can provide additional insights in the results. Examples of parametric tests that could be used—

if normality and other assumptions are not violated—are t-tests, ANOVA and regression. Consequently, effectiveness and usage might also be tested with other non-parametric tests such as contract testing, or a non-parametric regression. Especially since with the current data set, using QCA, recoding the data means losing valuable information. Another option to get more insights in the results is to perform a negated QCA, next to the original test. This implies that in addition to analysing which instruments lead to innovation, one can argue which instruments do not lead to innovation at all.

Furthermore, the questions in the questionnaire could be restructured when choosing QCA as the main test. Instead of asking 'how effective do you find the following instruments', one might ask: 'how effective do you perceive your government within the sticks category' while simultaneously asking participants which instruments their government uses within the stick category. This combines the usage and effectiveness analysis into one test. When using QCA, this can be done using percentages from zero to hundred instead of a 5-point Likert scale, which enriches the data set and the outcomes. Whereas these tests can be performed on a broader level (i.e. what is the perceived effectiveness of your government), these tests can also be performed on smaller scales, increasing the practical relevance (i.e. what is the perceived effectiveness of this innovation project). Another opportunity might lie within the combination of qualitative and quantitative data. Whereas this study focuses on qualitative data provided by public procurement experts, instruments effectiveness is occasionally measured using instrument reports, such as the Dutch SBIR evaluation. Future research could compare the formal evaluation of existing instruments with perceived effectiveness by practitioners. In addition, one can consider investigating barriers towards public procurement of innovations.

Lastly, this study is to the authors knowledge the first (exploratory) study providing a framework of public procurement innovation policy instruments. Expanding and validating the demand-side instruments and categorizations in this framework should prove to be beneficial. This can for example be done by investigating countries that were not within the sample size of this study. In addition, the framework can be expanded by including supply-side innovation instruments within the framework.

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Appendix I: frequency table R&D funding

R&D funding	SBIR	Challenges	PCP budget	co-financing	Award	insurance	catalogues	contracts
Australia	X							
Austria		X						
Belgium				X				
Canada		X						
China							X	
Denmark								
Estonia				X				
Finland								
France								
Germany				X	X			
Greece			X					
Ireland	X							
Italy			X					
Korea	X					X		
Lithuania								
Netherlands	X							
New Zealand								
Portugal								
Russia								X
Spain		X		X				
Sweden								
UK	X							
US	X							
Total	6	3	2	4	1	1	1	1

Questionnaire
Innovation through public procurement
The usage and effectiveness of public procurement innovation instruments

All responses will be treated with ABSOLUTE CONFIDENTIALITY. Survey results will be aggregated and anonymised.
MANY THANKS IN ADVANCE FOR YOUR PARTICIPATION
Esmee Peters
esmeepeters95@gmail.com
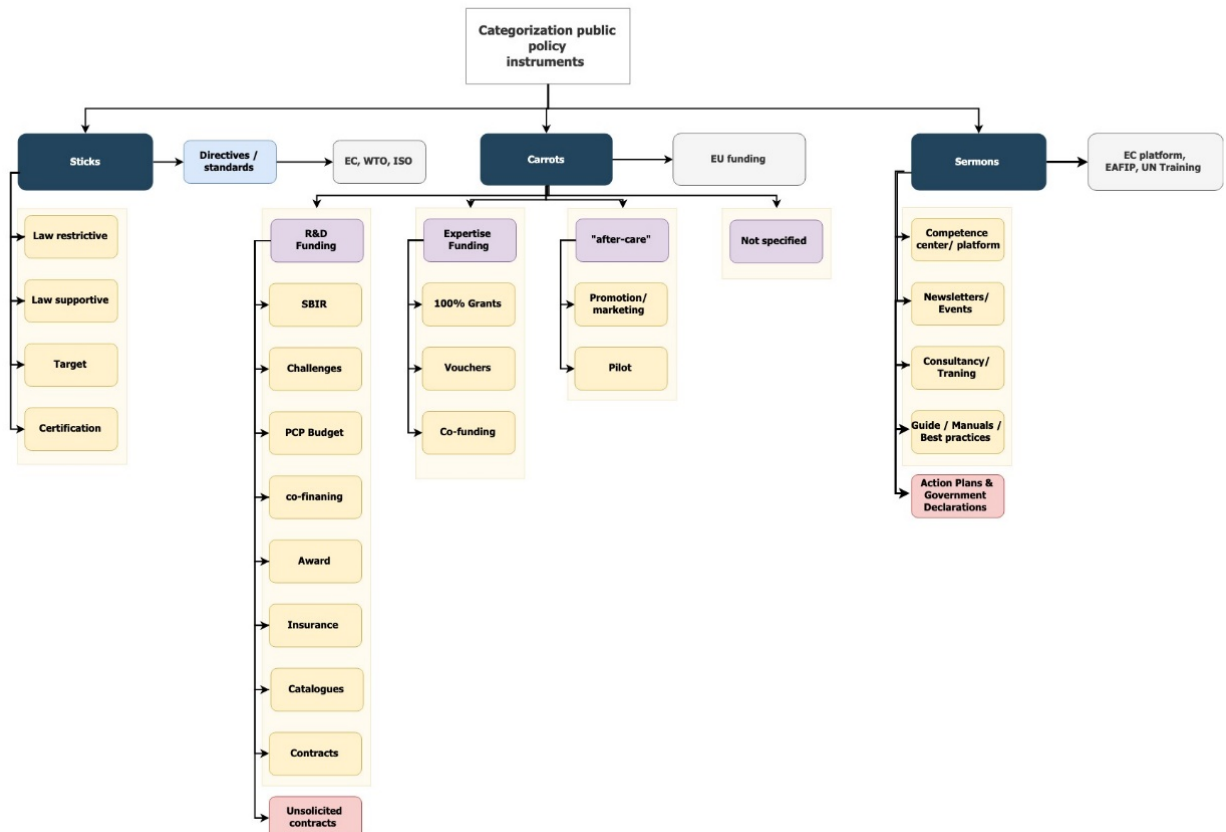
A1. Your contact email (optional):

Click here to enter text.

A2. Country where you are based:

Click here to enter text.

USAGE

B1. To what extent did you make use of public procurement innovation policy instruments?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
To what extent did you make use of public procurement innovation policy instruments?					

B2. To what extent did you make use of the following three categories in terms of public procurement innovation policy instruments:

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Sticks (formal regulation)					
b. Carrots (materialistic resources)					
c. Sermons (knowledge transfer)					

B3. To what extent did you make use of formalized regulation instruments in the category of "sticks" to promote innovation:

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Restrictive laws					
b. Supportive laws					
c. Targets					
d. Certification					

B4. To what extent did you make use of the following subcategories in the category of "carrots" to promote innovation:

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. R&D funding (in general)					
b. Expertise funding (in general)					
c. "after care" funding (in general) (e.g. marketing, pilots)					
d. A specified government budget for unspecified financial instruments					

B5. To what extent did you make use of R&D instruments to promote innovation:

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. SBIR					
b. Innovation Challenges					
c. PCP					
d. Co-Funding					
e. Public Procurement Innovation Awards					
f. Insurance					
g. Catalogues					
h. Contracts					
i. Unsolicited proposals					

B6. To what extent did you make use of instruments in the category of "sermons" to promote innovation:

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Competence centers / innovation platforms					
b. Newsletters and/or events					
c. Consultancy and/or training					
d. Guides, manuals, best practices					
e. Government declarations, government action plans					

EFFECTIVENESS
C1. Do you think public procurement innovation policy instruments are effective?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Do you think public procurement innovation policy instruments are effective?					

C2. How effective do you think that the following categories are?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Sticks (formal regulation)					
b. Carrots (materialistic resources)					
c. Sermons (knowledge transfer)					

C3. How effective do you think that the following instruments are?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. Restrictive laws					
b. Supportive laws					
c. Targets					
d. Certification					

C4. How effective do you think that the following sub-categories are?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. R&D funding (in general)					
b. Expertise funding (in general)					
c. "after care" funding (in general) (e.g. marketing, pilots)					
d. A specified government budget for unspecified financial instruments					

C5. How effective do you think that the following instruments are?

	Not at all	A small extent	A moderate extent	A large extent	A very large extent
a. SBIR					
b. Innovation Challenges					
c. PCP					
d. Co-Funding					
e. Public Procurement Innovation Awards					
f. Insurance					
g. Catalogues					
h. Contracts					
i. Unsolicited proposals					

C6. How effective do you think that the following instruments are?

	Not at all 1	A small extent 2	A moderate extent 3	A large extent 4	A very large extent 5
a. Competence centers / innovation platforms					
b. Newsletters and/or events					
c. Consultancy and/or training					
d. Guides, manuals, best practices					
e. Government declarations, government action plans					

C7. In general, why would you argue that public procurement innovation policy instruments are (not) effective?

Appendix IV: Consistency Table Effectiveness

Out come	causal conditions	measure	fully in	mostly in	more in than out	mostly out	fully out	mean	STD	min	max
General usage	stick usage	*To what extent did you make use of the following three categories in terms of public procurement innovation policy instruments?*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.26	1.251	1	5
	carrot usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.09	0.997	1	5
	sermon usage	*Sticks (formal regulation), carrots (materialistic resources), sermons (knowledge transfer)*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.5	1.18	1	5
Sticks usage	restrictive laws usage	*To what extent did you make use of formalized regulation instruments in the category of "sticks" to promote innovation? restrictive laws, supportive laws, targets, certification*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.38	1.209	1	5
	supportive laws usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.83	1.129	1	4
	targets usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.79	1.179	1	5
	certification usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.61	1.234	1	5
Carrot usage	R&D funding usage	*To what extent did you make use of the following subcategories in the category of "carrots" to promote innovation? R&D funding, Expertise Funding, aftercare funding (e.g. marketing, pilots), a specified government budget for unspecified financial instruments*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.51	1.103	1	5
	expertise funding usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.71	1.083	1	5
	after care usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.54	1.179	1	5
	non-specified usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.25	1.26	1	5

Outcome	causal conditions	measure	fully in	mostly in	more in than out	mostly out	fully out	mean	STD	min	max
			A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)				
R&D funding usage	SBIR	*To what extent did you make use of R&D instruments to promote innovation? SBIR, Innovation Challenges, PCP, Co-Funding, Public Procurement Innovation Awards, Insurance, Catalogues, Contracts, Unsolicited Proposals*	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.17	1.029	1	4
	Innovation Challenges		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.35	1.152	1	4
	PCP		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.5	1.102	1	4
	Co funding		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.42	1.06	1	4
	Awards		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.61	1.305	1	5
	Insurance		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	1.78	0.998	1	4
	Catalogues		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.26	1.137	1	4
	Contracts		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3	1.279	1	5
	Unsolicited proposals		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.14	0.964	1	4
Sermon usage	Competence center usage	To what extent did you make use of instruments in the category of "sermons" to promote innovation? competence centers / innovation platforms, newsletters and/or events, consultancy and/or training, guides/manuals/best practices, government declarations and/or action plans	A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.77	1.541	1	5
	Newsletters & events usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.96	1.147	1	5
	Consultancy & training usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.21	1.285	1	5
	Guides usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	3.29	1.334	1	5
	Government declarations usage		A very large extent (5)	A large extent (4)	A moderate extent (3)	A small extent (2)	Not at all (1)	2.83	1.39	1	5

Appendix V: Truth tables QCA, effectiveness

Sticks	Carrot	Sermon	General	number	Cases	Consist.
1	1	1	1	17	Serbia, Netherlands, Japan, Bhutan, United Kingdom, Indonesia, South Africa, Nigeria, Republic of Yemen, Kosovo, USA, Norway, Scotland, Italy, Hungary, Afghanistan, Kenya	0.979
0	1	1	1	2	Slovenia, Argentina	0.941
0	0	0	0	2	Wales, Germany	0.836
0	1	0	1	1	Belgium	1
1	1	0	1	1	Poland	0.963
0	0	1	1	1	Sweden	0.923

Table 26: fs QCA analysis, truth table general effectiveness

Restrict-ive	Support-ive	Target	Certifi-cation	Sticks	number	Cases	Consist.
1	1	1	1	1	12	Serbia, Japan, Bhutan, Germany, United Kingdom, South Africa, Republic of Yemen, Kosovo, USA, Norway, Italy, Afghanistan	1
0	1	1	0	1	5	Sweden, Netherlands, Slovenia, Argentina, Scotland	0.905
0	1	1	1	1	3	Indonesia, Nigeria, Hungary	0.972
0	0	0	0	0	2	Wales, Kenya	0.859
1	1	0	0	1	1	Poland	1

Table 27: fs QCA analysis, sticks effectiveness

RD	Expert	After-care	Un-specified	Carrot	number	Cases	Consist.
1	1	1	1	1	14	Japan, Germany, Poland, Slovenia, United Kingdom, Indonesia, South Africa, Yemen, Kosovo, USA, Norway, Hungary, Afghanistan, Kenya	0.973
1	1	1	0	1	3	Serbia, Belgium, Nigeria	0.968
1	0	1	0	1	2	Sweden, Argentina	0.960
0	1	1	1	0	2	Wales, Netherlands	0.889
0	0	0	0	0	1	Bhutan	0.888

Table 28: fs QCA analysis, truth table carrot effectiveness

COMP Cen.	NEWS	CON	GUIDES	GOV DEC	SERMON	num	Cases	Consist
1	1	1	1	1	1	12	Afghanistan, Italy, South Africa, Indonesia, Kosovo, Yemen, USA, Germany, Scotland, Poland, Kenya, Slovenia	0.944
1	1	1	0	0	1	3	Serbia, Japan, Belgium	0.923
1	1	1	1	0	1	2	Netherlands, Hungary	0.967
1	0	1	1	1	1	2	Nigeria, Norway	0.937
0	1	0	1	1	1	1	United Kingdom	1
1	0	1	0	1	1	1	Sweden	0.958
0	0	0	0	1	1	1	Wales	0.945
0	0	1	1	1	1	1	Bhutan	0.922

Table 29: fs QCA analysis, truth table sermon effectiveness

Appendix VI: External Questionnaire IRSPP