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Innovation and Public Procurement: Terminology, Concepts, and Applications⁺

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Abstract

The growing awareness of public procurement as an innovation policy tool has recently sparked the interest of both policy makers and researchers. While an increasing number of studies is being published every year, an overview of the field is missing. Researchers, practitioners, and policy makers are often using ambiguous wording and have not yet reached consensus on the terminology and concepts involved. This state of affairs leads to research fragmentation and lack of knowledge convergence. For the purpose of contributing to knowledge synthesis and consolidation, this article provides a structured review of the literature on innovation in public procurement. From categorizing publications based on innovation drivers, concepts, and research approaches, the emerging structure of the field is described and synthesized into a framework of innovation in public procurement. The proposed framework differentiates between literature streams on (1) innovations in the public procurement process, (2) innovation of public services by means of procurement, and (3) the use of public procurement as a tool for demand-side innovation policy-making. For each of these streams of literature, different focus areas as well as research gaps and opportunities for future research are identified. Based on analysis of existing research, the proposed framework provides an overview of state-of-the-art knowledge, a unified terminology, and a holistic understanding of innovation in public procurement. The framework is both a point of departure for future research and a source of knowledge for practitioners.

1. Introduction

Procurement of products and services by public institutions—public procurement—is recognized as a major market force. OECD member states spend on average 13 per cent of their GDP on public procurement, accounting on average for 29 per cent of total government expenditures (OECD, 2015). In most countries, (government) regulations are in place to ensure that this money is spent "with high standards of conduct" (OECD, 2015, p. 136). This has led to the prevailing notion of "efficiency in procurement [...] as a way to obtain the desired goods or services at the lowest price" (European Commission, 2015).

Aside from the primary purpose of public procurement to fulfill the needs and demands of the public administration, policy makers show an increasing interest in utilizing the massive buying power of the public sector as a tool to support secondary goals and policy initiatives, e.g. green and sustainable procurement, support for small- and medium sized enterprises (SMEs), and innovation. More than 90 percent of OECD

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member states have initiated policies or strategies pursuing such initiatives, though reports on the results are missing (OECD, 2015, p. 138). In this article, the focus lies on innovation initiatives within public procurement.

Balancing the efficiency and cost-effectiveness on the one hand and innovation on the other hand often leads to situations of conflict. Moreover, regulations and control mechanisms in public procurement limit buyers' freedom of action. While private sector investments in innovation sometimes follow "trial-and-error" patterns, public spending is often subject to rigid rules and a demand for traceability and accountability, which pose major challenges for policy makers who want to invest in innovation.

In recent years, the academic community has shown an increasing interest in the topic (Rolfstam, 2012a). Research on innovation in public procurement constitutes an emergent, practice-oriented and inherently interdisciplinary field. Thus, current research is scattered across different reference disciplines, which calls for knowledge synthesis and consolidation.

In addition to traditional supply-side measures such as research funding and technology transfer, previous research has focused on public procurement as a demand-side tool for fostering innovation in the market place. Public procurement as part of the innovation policy mix (i.e. the set of laws, policies, and regulations designed to foster innovation), often referred to as "public technology procurement", has been the subject of in-depth investigations (see, e.g., Edquist, Hommen, & Tsipouri, 2000; Edquist & Zabala-Iturriagagoitia, 2012, 2014). However, researchers have pointed to limitations in the way innovation effects are conceptualized and measured, which focus too much on "celebrated examples such as the internet and semiconductors" and do not provide insights into innovation with regard to common goods and services. The full potential of innovation in public procurement is therefore not disclosed (Uyarra and Flanagan, 2010).

Following this argument, this study provides a structured review of the academic literature on innovation in public procurement, guided by the following three research questions:

- What is the current academic body of knowledge on the role of innovation in public procurement? [Review]
- How can existing research on innovation in public procurement be synthesized? [Synthesis]
- What are the limitations of current research and promising avenues for future investigation? [Directions]

This article contributes to extant research in two ways. First, by analyzing existing literature, three separate streams of research that lack integration are identified. In addition to the mainstream debate on public procurement as a demand-side tool in the innovation policy mix, two related literature streams are discussed: the use of procurement for public service innovation, and innovative methods and procedures for public procurement, such as pre-commercial procurement (PCP) and public-private partnerships (PPP). Based on a discussion of similarities and differences across these research streams, the article reveals gaps in state-of-the-art knowledge and proposes avenues for future research, adding to those mentioned in (Uyarra and Flanagan, 2010). Second, a synthesized conceptualization of innovation in public procurement is proposed, including a common terminology and definitions of key concepts. Based on an analysis of state-of-the-art knowledge, the

study discusses strengths and weaknesses of the current academic discourse, i.e. knowledge gaps, and carves out potential avenues for future research.

The remainder of the article is structured as follows. Section 2 describes the research methodology, detailing the literature search and analysis process. Section 3 provides an overview of extant literature and a descriptive analysis of the current body of knowledge. Section 4 contains a comparative, concept-based discussion of the literature streams identified, which focuses on synthesis of prior research, theoretical foundations, and conceptualizations of innovation. In section 5, the consolidated findings of the study are presented and used to discuss ongoing developments as well as implications for future research. Finally, Section 6 concludes the paper by summarizing the key contributions.

2. Methodology

For the purpose of searching the literature, the Web of Science (WoS) and Scopus citation databases were used. Combining the two databases facilitates an in-depth review of the literature by ensuring broad thematic and geographic coverage. The two databases complement each other by spanning multiple subject areas (e.g. natural and social sciences) and including publications from 1869 to 2015.

Preceding a systematic search for literature, browsing through highly cited papers for commonly used terms and concepts helped to avoid limiting the search to contemporary buzzwords and ignoring the historical legacy of the field. In addition, discussions among the authors strengthened intercoder reliability by sharpening the focus on relevant aspects of innovation in public procurement by distinguishing between two areas of concern: procurement of innovation (i.e. innovative public procurement to modernize public services) and procurement for innovation (e.g. public procurement as an innovation policy tool). Later, a third area was added - innovative public procurement (i.e. innovation of public procurement processes) - but initially not included for fear of broadening the scope too much by including publications describing any kind of change to public procurement processes.

2.1. Literature search

The literature search process followed nine steps.

First, a search for literature in Scopus using the following search string was conducted:

```
TITLE-ABS-KEY("procurement of innovation*" OR "procurement for innovation*" OR ppi OR ptp OR "public technology procurement" OR pcp OR "pre-commercial procurement" OR spp OR "sustainable public procurement")AND DOCTYPE(ar OR cp)
```

The search was limited to peer-reviewed academic contributions, including journal articles and conference papers (henceforth articles for short). While this limitation reduces the extent of the review, it enforces a focus on high quality publications within the field. This search yielded 44.442 documents.

Second, all abbreviations, i.e. "ppi", "ptp", "pcp", and "spp", were removed from the search string, since they yielded non-relevant articles within, for example, the field of medicine. The modified search returned 28

documents. 21 articles were selected for further study. The relevance of some articles could not be determined based solely on the title, which required a reading of the abstracts. Articles dealing with sustainable procurement were discarded due to their lack of innovation focus.

Third, the same search (step 2) was performed in WoS, resulting in 18 documents. However, due to overlap in search results across citation databases, no additional articles were added to the pool of relevant literature.

Fourth, the search was expanded to include additional publications on "innovative procurement" and "innovation procurement" while excluding articles from the initial search (step 2). Applying the updated search string in Scopus yielded another 51 documents—23 of which were selected for further study.

Fifth, repeating the same search in WoS resulted in 16 new documents—6 of which were selected for further study.

Sixth, having read the abstracts of the identified articles, a decision was made to include publications focusing on public-private partnership as an innovation driver in procurement. This search did not, however, provide any new articles.

Seventh, based on an in-depth discussion of selection criteria, articles dealing with innovative procurement concepts and methods were included, reversing the previous decision to discard articles focusing on innovation in procuring non-innovative products and services. Consequently, all previously discarded articles were evaluated again. This resulted in 11 articles being selected for further study.

Eighth, back- and forward searches were performed based on the previously identified articles. As a result, five articles were added to the pool of literature to be reviewed.

Figure 1 provides an illustration of the literature search process.

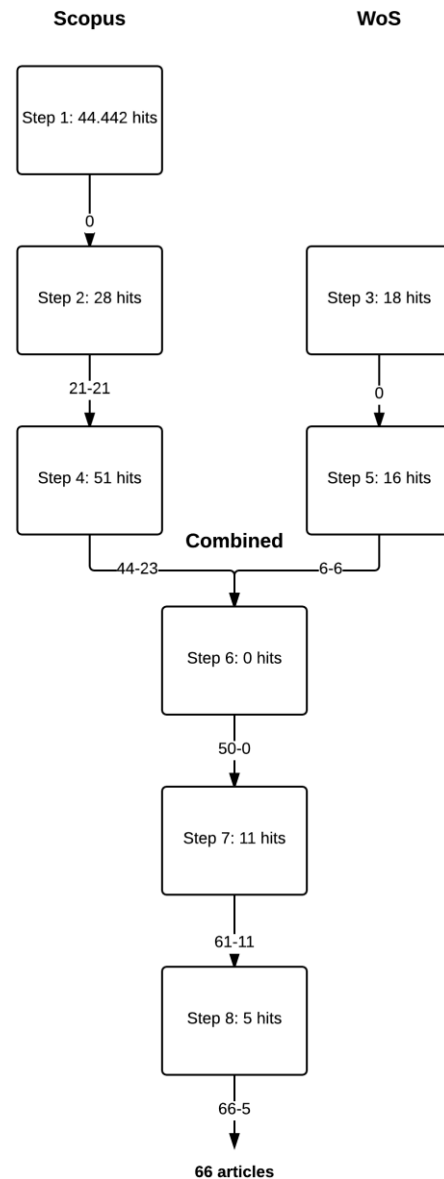


Figure 1: Literature search process

The decision to include or exclude an article was made collaboratively following a process of "check coding" (Miles and Huberman, 1994), which brought clarity with regard to the selection criteria and strengthened the reliability of the coding process. It was, however, necessary to discuss the relevance of selected articles, for example articles focusing on public-private partnerships. These articles were only included to the extent that the partnerships were innovative in nature. Articles dealing with procurement in general rather than procurement of innovations were discarded. The degree of inter-reviewer reliability was measured using Cohen's kappa (κ) (Spitzer et al., 1967), resulting in $\kappa = 0,94$, which indicates a high degree of agreement among the authors. Cohen's kappa was calculated as follows:

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)} = \frac{0.97 - 0.50}{1 - 0.50} = 0.94$$

Pr(a) is the relative observed agreement among the researchers, and Pr(e) is the hypothetical probability of chance agreement.

2.2. Literature analysis

For the purpose of analyzing the literature, a coding scheme was created through brainstorming. The coding scheme contains information regarding the title, author(s), and year of publication for each article. In addition, type of procurement was included to categorize the articles according to the aforementioned literature streams. In order to group the articles, various codes were included such as domain or industry of the study, region or country of concern, nature of contribution (descriptive or prescriptive), and application of theory (theoretical basis for the study). Finally, the Excel sheet contains information about contributions, identified challenges (with regard to innovation in public procurement), tools (tools, systems, methods, techniques, processes, and other solutions to procurement related tasks), terminology (concepts and acronyms used), and conceptualizations of innovation (definitions of innovation).

Second, the authors coded several articles together—both theoretical and empirical articles. This included reading the articles individually and discussing how to categorize them using the coding scheme. The purpose was twofold: First, to test the applicability and comprehensiveness of the scheme. Second, to reach a common understanding of how to use the coding scheme. Based on these discussions, additional codes were added to the coding scheme: outlet (journal or conference name), nature of any empirical data (whether quantitative or qualitative), conceptualization of procurement (definition of procurement type), and knowledge gaps (identified lack of knowledge).

Table A.1 in Appendix A illustrates the use of the coding scheme for all 66 articles.

Third, the authors coded five articles each individually. During this process, the need to write notes into the Excel sheet arose in order to capture useful quotations and reflections discovered while reading the articles. Subsequently, based on a discussion of the analysis results, a common understanding of the codes and their application was established.

3. Descriptive results [Review]

The review of existing literature reveals that the scientific discourse on innovation in public procurement has gained increased attention over the last decades. Although practitioners may have considered the benefits and challenges of innovation in public procurement even earlier, this is not directly reflected in scholarly publications. As seen in Figure 2, the topic has gained traction among researchers since the year 2000 and remains an active field of research today. A large part of the 66 selected articles (more than 80 percent) has been published since 2001.

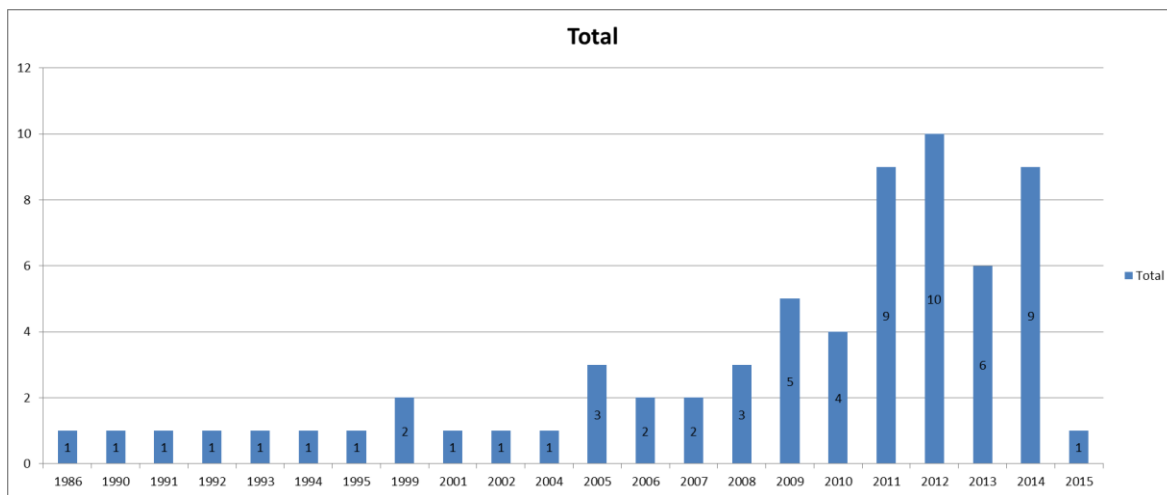


Figure 2: Publications by year.

Overall, relatively few articles have been published every year with an increase since 2005. There are two possible explanations for this pattern.

Firstly, the topic is practitioner-oriented. Procurement activities are carried out by employees who do not have a tradition for publishing their results in academic journals. Moreover, in emerging fields it is commonplace that practice is ahead of research (Ågerfalk and Fitzgerald, 2006). Secondly, the reported studies are performed by scholars with backgrounds in innovation research. Many articles therefore apply an innovation perspective while paying scant attention to the public procurement aspects. Buyers in public procurement agencies find it difficult to relate to the abstract, theoretical concepts used in these studies. Thus, this study confirms previous findings pointing to the gap between the needs of practitioners on the one hand and the output by the innovation research community on the other hand (Rolfstam, 2012a).

The majority of articles focus on European cases (39) with Britain being the most frequently investigated (16). In comparison, only 9 publications are based on empirical data from the United States and Canada (1). Another 9 articles do either not disclose the region in which research took place or present findings independent of region. Moreover, while the majority of publications from North America describes specific innovations in the procurement process, the majority of European articles focus on the use of public procurement as an innovation policy tool.

In terms of industry, many articles (24) do not focus on any particular application domain. A sizeable part (23) deals with the construction industry. The other represented industries are: healthcare (6), infrastructure (2), and energy (2).

As previously mentioned, the review includes peer-reviewed journal articles and conference papers. 16 articles were published at (predominantly construction related) conferences—50 in journals. Conferences, such as the ARCOM (Association of Researchers in Construction Management) conference, are main outlets for research on procurement processes within the construction industry. Overall, the 66 studies included in the review were

published in 48 different outlets—a fact that strengthens the impression that as of yet there is no convergence within the field. This situation is in part explained by the inter-disciplinarily and emergent nature of the field.

The analysis of articles in our sample shows a balance between theoretical (24) and empirical articles (42). Many empirical studies are based on qualitative (27) or mixed-methods research methodologies (3) in the form of single (19) or multiple case studies (10), which are built largely on interviews, observations, and document analyses. Some articles (12) rely solely on quantitative methodologies. Data used for quantitative analyses were predominantly gathered using large scale surveys and panels, e.g. the Mannheim Innovation Panel (Centre for European Economic Research, 2015) in (Aschhoff and Sofka, 2009). Almost all articles (62) contain descriptive results, while only four articles present prescriptive models.

4. Concept centric analysis [Synthesis]

As part of the effort to synthesize prior literature at a meta-level, three categories of literature were identified: innovations in the public procurement process (30), innovation of public services by means of procurement (8), and the use of public procurement as a tool for demand-side innovation policy-making (25). While most articles fall within one of these categories, they are not mutually exclusive. Some articles, such as (Aschhoff and Sofka, 2009; Guerzoni and Raiteri, 2015; Timmermans and Zabala-Iturriagoitia, 2013) are contributing to more than one research stream and have thus been categorized based on their main contribution. Moreover, three articles are written on a higher level of abstraction and provide insights across categories (Edquist and Zabala-Iturriagoitia, 2012; Hommen and Rolfstam, 2009; Uyarra and Flanagan, 2010). These are categorized as "public procurement and innovation" (PPaI). This approach to categorization enables a clarification of key concepts and establishment of a clear terminology. Concepts and definitions change over time with increasing maturity in emerging fields of study (Fink, 2014; Webster and Watson, 2002), and this review therefore provides a snapshot of state-of-the-art knowledge of innovation in public procurement. The resulting overview allows for the identification of knowledge gaps and contributes to greater conceptual clarity, which paves the way for future studies. In the remainder of this article, contributions to the literature are categorized based on the conceptual distinction between:

- public procurement for innovation (PPfI),
- public procurement of innovations (PPoI), and
- innovative public procurement (IPP).

Moreover, the concept of public procurement and innovation (PPaI) is used for contributions that transcend these categories. Table 1 shows the distribution of articles across literature streams and topics.

	Literature streams		
Topics	PPfI	PPoI	IPP
	<u>Policy mix</u> (Vecchiato and Roveda, 2014) (Edquist and Zabala-	<u>Public service policies</u> (Stillesjoe, 1993) (Nilsson, 1991)	<u>Innovative procurement models</u> (Boes and Dorée, 2008) (Lam and Gale, 2014)

	Iturriagagoitia, 2014) (Lember et al., 2010) (Dalpé et al., 1992) (Guerzoni and Raiteri, 2015) (Rullan et al., 2012) (Edler & Georghiou, 2007) (Timmermans and Zabala-Iturriagagoitia, 2013) (Myoken, 2010) (Borrás and Edquist, 2013) (Dalpé, 1994) (Edquist and Hommen, 1999) (Geroski, 1990)		(Witteveen and Doree, 2011) (Khalfan, Arif, & Aburas, 2008) (Manase and Brown, 2011) (Boes and Dorée, 2011) (Kashiwagi, 2002) (Kashiwagi, Parmar, & Savicky, 2004) (Cruz and Marques, 2014) (Goodchild and Chamberlain, 1999) (Jeffcoat et al., 2005) (Edwards and Holt, 2011) (Carpintero and Marañá, 2009)
	<u>Impact analysis</u> (Caerteling et al., 2009) (Aschhoff and Sofka, 2009) (Georghiou et al., 2014) (Peng and Cai, 2008) (Edler, Georghiou, Blind, & Uyarra, 2012)		<u>Procurement strategies</u> (Khalfan, 2011) (Lu et al., 2013) (Liu and Wilkinson, 2011) (Pena-Mora and Harpoth, 2001) (Pryke, 2006) (Eadie et al., 2013) (Keating and Wade, 1986)
	<u>Critical success factors and barriers</u> (Rolfstam, 2012b) (Phillips et al., 2007) (Rolfstam et al., 2011) (Caldwell et al., 2005) (Uyarra et al., 2014) (Rolfstam, 2012a) (Rolfstam, 2009)	<u>Innovation management</u> (Yeow and Edler, 2012) (Gee and Uyarra, 2013) (Kalvet and Lember, 2010) (Valovirta, 2012) (Gianakis and Mccue, 2012) (Kalvet, 2012)	<u>Procurement process guidelines</u> (Vogel, 2010) (Laryea and Watermeyer, 2014) (Klingler et al., 2014) (Cicmil and Marshall, 2005) (Knutsson and Thomasson, 2014) (Alli et al., 2012) (Chenggang et al., 2006) (Feltham, 1995) <u>Information technology</u> (Johnson and Robinson, 2014) (Lewis et al., 2011)

Table 1: References by streams and topics

The following subsections are structured according to each of the identified research streams, i.e. PPfI, PPol, IPP, and PPal. The synthesis of each stream revolves around main topics, e.g. public service policies and innovation management in PPol, and each topic is described within the corresponding stream. Based on the syntheses, subsection 4.5 illustrates the relationship between research streams in a synthesized framework of innovation in public procurement (Figure 3). This framework in turn leads to a discussion of the theoretical foundation of existing research and the concept of innovation in the literature (subsection 4.6 and 4.7 respectively).

4.1. Public procurement for innovation (PPfI)

The literature search resulted in 25 articles discussing how to include public procurement in innovation policy mixes and thereby use public procurement as a demand-side tool to drive innovation. (Edler & Georghiou, 2007, p. 950) describe the purpose of this research stream as investigating the "use of public demand as an

engine for innovation". Most studies investigate European initiatives and arise from the perception "that traditional supply-side innovation policies are insufficient to meet the challenges posed in promoting competitiveness" (Edler & Georghiou, 2007, p. 952). In general, this literature stream is grounded in innovation research. Thus, public procurement is seen as one of several instruments to address the question of how to design an optimal innovation policy mix (13 articles). Five studies investigate how to evaluate and measure the impact of such demand-side innovation policies in contrast to traditional supply-side instruments. Seven articles identify and analyze the influence of specific factors on buyers and suppliers (including contractual or tendering practices, supplier management approaches, and the creation of procurement organizations) when public procurement is used as part of the innovation policy mix.

Policy mix

Historically, the public sector has been an influential first mover in the use of innovations, patents, and products, particularly in R&D intensive industries such as the railroad, communications, scientific equipment, and pharmaceutical industries (Dalpé et al., 1992). However, the public sector influences innovation activities regardless of whether an explicit PPI policy exists or not. The specific mix of different policy instruments, including regulations (e.g. laws), economic transfers (such as PPfI), and soft instruments (e.g. recommendations and non-binding contractual agreements), has to be designed using a structured approach, since policy instruments are frequently used ad hoc without attention to overall goals (Borrás and Edquist, 2013).

To investigate how to establish structured procurement policies that purposefully foster industrial innovativeness, four different types of policy can be distinguished: procurement policies, government regulations, subsidies, and investments in infrastructure (Geroski, 1990). Whereas the former two are considered to be on the demand side in stimulating innovation, the latter two are supply-side measures. Research shows that policies are generally more effective than R&D subsidies in stimulating industrial innovation, however, Geroski (1990) stresses the need to avoid dependency on public contracts for the long-term sustainability of the industry. More specifically, Dalpé (1994, p. 78) finds on the basis of multiple case studies that "the most important factors that positively affect the demand for new products and supplier innovation are: the technological capacity of the public sector user, particularly when it acts as the lead user; the value of orders, which allows the supplier to reduce the risk associated to innovation; and the relation between needs and requirements."

For the purpose of deriving policy guidelines, Edquist & Hommen (1999) apply systems of innovation thinking (Edquist, 1997) and analyze five different theoretical perspectives on innovation. First, the chain-linked model of innovation emphasizes policies in support of establishing chains of innovation. Second, the distributed process model stresses that manufacturers are not always the source of innovation, and policies are needed to promote, e.g., lead-users and lead-markets. Third, interactive learning theory points to the quality of user feedback as more relevant to innovation efforts than the quantity of comments. Policies may support feedback mechanisms through information brokerage. Fourth, network analysis highlights the need for intermediates as providers of vertical linkages between innovators and users. Fifth, development block theory suggests that policies may support the creation of knowledge clusters in areas where entrepreneurs are not present without external incentives. The authors argue that each of the different theories can be used as a complementary

"component of a broader [systems of innovation] policy perspective—much as the various 'appreciative' theories and models with which they were originally associated have since been incorporated into a broader set of theoretical perspectives on systems of innovation" (Edquist and Hommen, 1999, p. 75).

In a recent review, Edler & Georghiou (2007) underscore the lack of demand-side measures in stimulating innovation activities and propose four focal areas in addressing this deficiency: First, they suggest a change of rationale and establishing inter-organizational strategies to foster common understandings among actors across the public administration of how public procurement influences innovation cultures. Second, they stress that linking public and private demand, known as catalytic procurement, may affect diffusion of innovation positively. Third, the authors call for strategies for coping with the complexity issue in the procurement discourse, which translates "to bring future needs and future supply together at an early stage" (Edler & Georghiou, 2007, p. 959). Finally, they recommend nurturing procurement chains, i.e. a "structure in which procurers are very close to or even involved in the daily business of their administrations" (Edler & Georghiou, 2007, p. 960). This fosters greater understanding of the needs and demands of the public administration.

A number of studies have added to the policy mix debate from different levels of public administration. At the level of city management, Lember et al. (2010) analyze procurement in six Baltic cities and find that urban competitiveness and public procurement are positively related. In addition, they point to the need for change in public procurement cultures away from risk avoidance toward risk management. Investigating governmental procurement policy at the country level in Argentina, Brazil, Chile, and Mexico, Rullan et al. (2012) find the countries lacking in administrative and policy competency in terms of PPfI and call for more innovation-stimulating public policies. Specifically, "a guideline for procurers to create, support and identify more innovative proposals by suppliers" in order to "prevent waste, fraud and corruption" is proposed (Rullan et al., 2012, p. 600). In a historical account of R&D spending in Japan, (Myoken, 2010) finds that R&D investments have been successful to the extent that Japan was able to export its innovative products, e.g. electronics, to the United States and other big markets. However, due to trade barriers, Japan has also had to find ways of commercializing innovations on the home market. The author envisions PPfI initiatives and policies as valuable demand-pull tools in support of such commercialization. At the industry level, it is suggested that experiences from the American so-called Small Business Innovation Research program (Office of Investment and Innovation, 2014) offer lessons learned in encouraging SMEs to partake in government tenders, using intermediaries to evaluate emerging technologies and facilitating matchmaking between suppliers and buyers. At the country level, Vecchiato & Roveda (2014) propose the use of foresight based on their study of public procurement in the Italian region of Lombardia where such activities lead to observable benefits in terms of higher awareness of societal needs, enhanced citizen-participation, and increased governmental transparency. Based on three cases from the Netherlands, Britain, and Australia, Edquist & Zabala-Iturriagoitia (2014) challenge the role of Pre-Commercial-Procurement (PCP) as a demand-side policy instrument. They find that "the procurements (selling and buying) that may follow PCP processes may be regarded as examples of the acquisition of off-the-shelf products (the prototypes for which have been developed in the PCP process), that is, it becomes a matter of regular procurement" (Edquist and Zabala-Iturriagoitia, 2014, p. 10).

Attracting and supporting higher involvement and participation of SMEs in the context of PPfI is a challenge for many public procurement agencies. Timmermans & Zabala-Iturriagagoitia (2013) propose "coordinated unbundling" as a method to break down larger tenders and thereby foster knowledge-intensive entrepreneurship (KIE). The authors argue that because of the organizational size of KIEs and SMEs, public procurement must allow for tasks to be divided into smaller, manageable units, in order to "provide stimuli to smaller organisations to participate and thereby, indirectly, reserving spots for them in the procurement process" (Timmermans and Zabala-Iturriagagoitia, 2013, p. 6).

As one of the few studies based on a quantitative research design, Guerzoni & Raiteri (2015) investigate the impact of supply-oriented (R&D subsidies and tax credits) and demand-oriented (e.g. public procurement) measures of innovation in companies, focusing in particular on the interaction between different policy tools. A large dataset from a European Innobarometer study, comprised of more than 5000 companies, is analyzed in a quasi-experimental setting. The authors identify a "reinforcement effect of public support on private innovation" (Guerzoni and Raiteri, 2015, p. 745) and point to the existence of "a procedural confounding effect produced by innovative public procurement as a hidden treatment" (Guerzoni and Raiteri, 2015, p. 745). Thus, the authors conclude that public procurement—both as separate policy and as part of policy mixes—is useful as an instrument to encourage innovative behavior.

Impact analysis

As public procurement agencies are often subjected to scrutiny and public attention, accounting for the impact of potentially risky procurement behavior is crucial. However, with a change from predominantly supply-side policies to an emphasis on the demand side (including PPfI), evaluation strategies have to be adapted accordingly (Edler et al., 2012).

Peng & Cai (2008) propose three specific impact measurement criteria for PPfI: service quality, efficiency, and effectiveness. Specifically, effectiveness, i.e. the government's ability to stimulate innovation through public procurement (PPfI), is measured looking at input, process, output, and outcome. The input is the increased investment in innovation by companies having won or hoping to win government contracts. Process is the improvement of the companies' innovation capabilities as an effect of the government's innovation policy. The output is measured externally in terms of patents and social benefits. The outcome is determined internally by the companies' abilities to transfer patents into cash flow, resulting in financial benefits to the companies. The three key criteria are broken down into 21 evaluation indices—both quantitative and qualitative—that allow for the measurement of public procurement for innovation performance. Georghiou et al. (2014) develop a more differentiated framework of PPfI measures based on a survey of 800 suppliers in Britain. They differentiate between measures of "the creation of framework conditions, establishing organisational frameworks and developing capabilities, identifying, specifying and signaling needs, and incentivising innovative solutions" (Georghiou, Edler, Uyarra, & Yeow, 2014, p. 1). For each policy measure they describe different types of instruments and provide examples. The authors conclude from the survey how collaboration between suppliers and public buyers fosters innovation. This results in issues that need addressing from a supplier perspective: (i) procurement policies are fragmented and not easily accessible, (ii) policies do not reflect involved agencies' perspectives but are written on a more generic level, (iii) favoritism shown to

national and local versus innovative suppliers, (iv) policies do not include perspectives on adoption, and (v) lack of risk management awareness and knowledge in the public sector. Edler et al. (2012) propose an evaluation framework based on a case study of six markets (construction, textiles, bioproducts, recycling, renewables, and eHealth) included in the European Lead Market Initiative. The framework comprises three steps, namely market delineation, formation of and impact on actors, and impact on markets. In addition, they propose different evaluation teams for each market, since "the six markets are so complex and indeed very different in the actor representation and in the ways they can be delineated and economic developments can be measured" (Edler et al., 2012, p. 10).

To investigate the impact of PPfI on manufacturing and service industries in Germany, Aschhoff & Sofka (2009) analyze data from the Mannheim Innovation Panel and are able to quantitatively demonstrate the positive effects of PPfI, only surpassed by spillover effects from university based research in terms of impact on market success. Similarly, Caerteling et al. (2009) perform a quantitative analysis of effects of government championing behavior and Public Technology Procurement (PTP) on the performance of technology development projects in road construction in the Netherlands. They find that both championing behavior and PTP have positive effects on project performance (although the effect of PTP is negligible). They identify, however, a negative impact of PTP on customer benefits as perceived by contracting firms. They offer two possible explanations of this puzzling finding: "First, lowest bid selection favors existing technologies with minor improvements because new technologies with significant improvements are more costly than existing technologies. Second, public technology procurement rarely asks for significant improvements compared to existing technologies, as this might exclude too many firms" (Caerteling et al., 2009, p. 1216).

Critical success factors and barriers

A number of researchers have studied the key success factors as well as barriers for the efficient and effective use of PPfI as innovation driver. Caldwell et al. (2005) investigate three cases from Britain and find that key success factors include particular contractual or tendering practices (e.g. locking out suppliers from the market), management oversight of key suppliers (e.g. through continuous supplier development), and the need for post-contract management (e.g. capturing lessons learned and evaluating performance). Other researchers highlight the importance of having a champion and an organizational anchor throughout the project, especially in distributed settings (Phillips et al., 2007). Based on a series of studies using an institutional theory frame, Rolfstam (2009, 2012a, 2012b) finds the failure or success of PPfI initiatives to be dependent not only on exogenous institutions (such as policies or laws) but also on coordination activities at all institutional levels (including endogenous institutions), which help explain "situations where conflicting policies manifested in endogenous institutions among stakeholders lead to failure in public procurement of innovation" (Rolfstam, 2009, p. 358).

From a different perspective and with particular focus on the role of contractual design, Uyarra et al. (2014) investigate challenges from the perspective of suppliers to the public sector. Their findings show that, on the one hand, smaller companies experience difficulties with large contracts in public tenders. On the other hand, contracts are sometimes too small to leave room for innovation. Moreover, small firms are particularly concerned with lack of communication and feedback by public buyers.

4.2. Innovation of public services by means of procurement—public procurement of innovation (PPoI)

Eight articles in our sample describe the use of public procurement with the goal of modernizing the public administration and providing innovative goods and services to citizens. A common topic is how to change the behavior of public procurement agencies from buying the cheapest goods and services to investing in innovative albeit riskier solutions, i.e. basing procurement decisions on a long term perspective on strategic development rather than a short term perspective on price (Boes and Dorée, 2008; Eadie et al., 2013; Yeow and Edler, 2012).

All but two articles present case studies of how public institutions cope with the challenges of organizational change in response to investments in innovative solutions to public sector needs. Some contributions address the lack of risk management techniques for procurement purposes, which are crucial in managing the uncertainty and potential problems of procuring innovations. Others focus on different management challenges, e.g. project management, supply chain management (Gianakis and Mccue, 2012; Yeow and Edler, 2012), and institutional set-ups (Gee and Uyarra, 2013).

Public service policies

Different researchers (Nilsson, 1991; Stillesjoe, 1993) look at how the Swedish government introduced policy changes to increase the use of energy efficient technologies in the public administration and the general market. (Nilsson, 1991) describes the Swedish program to improve and introduce energy-efficient products and services. The paper describes three steps of transformation: early introduction of technology by means of public procurement, acceleration through demonstration by public institutions, and (self-driven) enlargement of the market. Furthermore, the article briefly describes a couple of examples of pre-commercial procurement, and the author argues that successful PPoI programs require consideration of four elements: technology, competitiveness, time, and actors (Nilsson, 1991, p. 149). On a more detailed level, (Stillesjoe, 1993) elaborates on the case of introducing energy-efficient lighting and ventilation technologies by public institutions. The new procurement policy included monetary incentives to construct and renovate locations using energy-efficient equipment. Through these incentives, policymakers aimed at stimulating research and innovation in the industries involved and supporting commercialization of innovative and energy-efficient technologies. As a result, the author concludes that "a technology procurement program is of great interest to purchasers as well as to contractors. The purchasers can meet somewhat more stringent energy-efficiency standards than their ordinary economic criteria allow" (Stillesjoe, 1993, p. 224).

Innovation management

Innovative procurement activities are often complex and in turn require management oversight and involvement to ensure success. In practice, procurement managers are therefore faced with new challenges in all phases of the innovation cycle, including R&D management, commercialization of innovations, as well as general project and risk management. Researchers acknowledge that "out-of-the-box procurement of innovation [...] needs a clear leadership, capacity and resources" (Yeow and Edler, 2012, p. 493). From a managerial perspective, public procurement of innovation is thus part of "a larger issue of innovation management in public organisations" (Valovirta, 2012, p. 3).

To address these challenges, a number of researchers focus on the question of how organizations may effectively deal with the need for new skills and knowledge that is required for successful public procurement of innovation. Valovirta (2012) investigates a case involving a large government organization and cities of varying sizes in Finland. In addition to acquiring general procurement skills, the study finds that strategic management, market interaction, risk management, coordination and communication, as well as capacity building are particularly important to PPol. Moreover, they argue that a "new kind of relationship between procurement and R&D is needed", and that "public procurement of innovation needs to be embedded as an instrument in the broader framework of public service renewal" (Valovirta, 2012, p. 8ff). Similarly, (Gianakis and Mccue, 2012, p. 137) recommend that procurement agencies move from a "transaction based focus and a pure control function to a value-added focus and a true strategic orientation", and thus switch from "fire-alarm" (re-active) to "police patrol" (pro-active) mode. This can be accomplished with the support of real-time data, managed through state-of-the-art IT systems (Gianakis and Mccue, 2012, p. 137).

From a risk management perspective, (Kalvet and Lember, 2010) look at five cases involving Baltic cities, investigating how risks are managed in procurement of innovations. The authors apply the general strategic risk framework developed by the European Union (Tsipouri et al., 2010) and find that "the public sector has to be able to deal with different kinds of process risks (from technology to turbulence risks)" while pointing out that "there are no signs that these risks are addressed through comprehensive risk management strategies" (Kalvet and Lember, 2010, p. 259). Similarly, looking at the specific case of e-government in Estonia, (Kalvet, 2012) points to private sector competencies and the actions of "ethical hackers" (in the sense of creative ICT workers) as crucial factors in managing risks of technology failures resulting from public procurement of innovation. Especially for small countries, incremental innovation of the public sector increases the chance of success, as demonstrated by numerous examples (e-voting, public-key infrastructure etc.) in the Estonian case.

The special case of managing innovation of systems, i.e. the innovation of entire systems of interconnected parts, actors, and institutions, is the focus of (Gee and Uyarra, 2013). The authors investigate how public procurement can be used to guide this type of innovation, looking into the case of the renewal of a waste management system. The project was a complex innovation due to the many changes associated with a change in technology, including questions of how and where to sort garbage and which governance structure to apply. The case "demonstrates how public bodies can, in some circumstances, orchestrate system transformation through procurement" (Gee and Uyarra, 2013, p. 1185). In addition to other management aspects, the article points to the need for centralized management of interdependencies in terms of processes and information sharing when dealing with innovation of systems. The need for controlling the information flow by public authorities is emphasized, thereby "developing the required interdependencies between technologies, institutions and practices" (Gee and Uyarra, 2013, p. 1185).

4.3. Innovations of the procurement process—innovative public procurement (IPP)

Almost half (30) of the 66 articles included in this review investigate innovations of the procurement process. These studies differ from the other 36 articles in their dealing with innovations in the procurement process and not procurement of innovative products and services. Many of the articles are published in highly specialized conference proceedings or journals (e.g. the conference of the association of researchers in construction

management—ARCOM) and are therefore somewhat decoupled from the general discourse on innovation in public procurement. Because innovations in the procurement process do not necessarily lead to the procurement of innovative solutions in support of particular markets or modernizing public services, this body of knowledge was included as a separate category. Within this category, three topics became apparent. First, seven studies investigate from a strategic perspective how procurement professionals and institutions may adopt innovative procurement methods. Second, eight articles look at various frameworks and methods for the procurement of specific products or services, mostly in the area of construction or infrastructure. Third, 13 publications focus on the process perspective, including procedures and guidelines for innovative public procurement. Finally, the remaining two articles present IT perspectives on IPP.

Procurement strategies

In terms of strategy, (Lu et al., 2013) describe at an abstract level how Chinese international construction companies perceive innovative public procurement and conclude that they "are gradually adopting procurement innovation as a competitive strategy" (Lu et al., 2013, p. 347), facilitating the delivery of societal value. Looking at Britain, (Eadie et al., 2013) investigate the impact of economic recession on preferred government procurement routes and suggest at a general level that "government policy should ensure that potential efficiencies through choice of route [are] not ignored" (Eadie et al., 2013, p. 24). At a more specific level, three articles focus on partnering in construction projects in New Zealand, Puerto Rico, and Britain (Khalfan, 2011; Liu & Wilkinson, 2011; Pena-Mora & Harpoth, 2001). (Liu and Wilkinson, 2011) investigate the adoption of public-private partnerships in New Zealand, identifying key drivers and obstacles (Liu and Wilkinson, 2011). In (Pena-Mora and Harpoth, 2001) lessons learned from the Tren Urbano Project are "generalized to apply them to any project that uses an innovative delivery method in a multiphase, multiparty, multidiscipline, and multicultural environment" (Pena-Mora and Harpoth, 2001, p. 8). The authors identify three categories—"project (initial)", "operational", and "resulting"—of interrelated factors that impact project outcomes. In particular, their analyses show that "to achieve fully effective partnering, strong initial meetings are important, but if the initial meetings are lacking slightly in effectiveness, follow-up meetings can ensure full partnering" (Pena-Mora and Harpoth, 2001, p. 10). (Khalfan, 2011) emphasizes how to integrate downstream supply chain members through partnering, resulting in time and cost savings, improved relationships among partners, and overall improvements in the construction process. The author recommends using pre-qualification questionnaires that include "questions related to quality, health and safety, turnover, references. etc.", leading to "Improved design; Less waste and duplication; Improved delivery; Greater certainty of cost; and Better whole life cycle costing" (Khalfan, 2011, p. 67). For their part, (Keating and Wade, 1986) describe another procurement strategy—a request for proposal purchasing methodology—used within the American healthcare sector for blood banking products, which includes a number of ranked award criteria as one of the most innovative features. These criteria help vendors develop their proposals and guide the evaluation committee. In addition to award criteria, the authors recommend using a multi-disciplined evaluation committee, which facilitates an unbiased review of proposals that take various stakeholder preferences into account (Keating and Wade, 1986). Lastly, (Pryke, 2006) reports on a case study of another British construction project "where a really determined effort was made to break the traditional mold in terms of attitudes and

relationships through procurement strategies. In doing this a new role of cluster leader is established operating within an informal relational contracting framework." (Pryke, 2006, p. 75).

Innovative procurement models

With regard to models, the literature contains different frameworks and methods for innovative procurement.

In terms of procurement frameworks, (Manase and Brown, 2011) describe the Frameworks Scotland initiative as an adoption of best practice in the procurement of publicly funded construction work. The Frameworks Scotland initiative was developed "as a strategic, flexible and collaborative procurement route for the design and construction of capital projects" (Manase and Brown, 2011, p. 234), and its benefits include improved working relationships, continuous improvements, reduced commercial risks, improved design, and improved decision-making. Successful partnering using a model like Frameworks Scotland requires, however, management of the collaboration scheme, including effective resource management of the framework (Manase and Brown, 2011).

Another aspect is the legal framework underlying public procurement. In investigating the transport infrastructure projects in the Madrid metropolitan area, (Carpintero and Maraña, 2009) identify the reliable environment created by Spanish procurement laws as "crucial for the procurement of infrastructure and public services projects by different public administrations at central, regional and local levels" (Carpintero and Maraña, 2009, p. 436). The maturity of the legal framework made the projects possible. Additionally, the tender mechanism—an open competitive process for the awarding of concession contracts—is also mentioned as a success factor, which also reduces the bidding costs of all involved parties. Last, but not least, the authors emphasize that the transparency of the process as well as the clarity of the evaluation criteria allowed for effective project proposal comparison.

Other studies have focused on the benefits of various innovative procurement methods (Jeffcoat et al., 2005; Kashiwagi, 2002; Khalfan et al., 2008). (Kashiwagi, Parmar, & Savicky, 2004) compare price-focused, low-bid, and performance-based methods, concluding that construction projects using the latter perform superiorly. Khalfan et al. (2008) present two case studies within the construction industry "showing how leading public sector clients have established innovative procurement processes and thinking, in order to integrate the downstream construction supply chain members; especially suppliers and manufacturers of products" (Khalfan et al., 2008, p. 74). The authors emphasize that the early and tight integration of suppliers along the supply chain enables better communication within and performance of construction projects, resulting "in development of innovative solutions by different manufacturers to different problems with an integrated approach" (Khalfan et al., 2008, p. 84). For their part, (Jeffcoat et al., 2005) describe pre-negotiation, pre-bidding, and pre-purchasing as three innovative methods for the procurement of equipment at three water treatment plants. The authors highlight the cost savings of "identifying the key process equipment components and determining the preferred vendor for specific equipment items, negotiating, bidding, or purchasing the equipment prior to the bidding of the project" (Jeffcoat et al., 2005, p. 2). In evaluating the current state of the procurement initiative by the Dutch government that aims at fostering the use of "innovative contract forms by local authorities" (e.g. "Design-Build"), (Boes and Dorée, 2008) show that many public authorities still use

traditional contract forms ("Design-Bid-Build"), which lead to low quality and non-sustainable but price-competitive products. In a more recent paper, the authors conclude that many public institutions in the Netherlands still prefer invited or selected tenders as opposed to the open, public tenders promoted by the EU. This preference makes a shift from price competition toward best value unlikely in the near future (Boes and Dorée, 2011).

Turning the attention to models, (Goodchild and Chamberlain, 1999) look at procurement in the area of social housing development in Britain, comparing client-led and contractor-led models, and suggest that no procurement method is universally superior (Goodchild and Chamberlain, 1999). (Kashiwagi, 2002) describes the so-called "Job Order Contracting" procurement model in the construction industry, evaluating its performance vis-à-vis other "methods of project delivery", and concludes that it is best for "delivering quick, economical, performing construction for the maintenance, repair, and renovation of facilities" (Kashiwagi, 2002, p. 20). Similarly, (Witteveen and Doree, 2011) investigate the introduction of the so-called BVP/PIPS procurement model (the Best Value Procurement/Performance Information Procurement System) to Dutch road construction projects and conclude that in comparison with previous models it shows positive impacts on time, budget, quality, and client satisfaction (Witteveen and Doree, 2011). (Lam and Gale, 2014) investigate the financial performance of framework- vs. tender-based projects in highway construction in Britain. The authors analyze differences in production costs (tender value) and transaction costs (including both engagement costs that accrue during the initial phase of projects and performance monitoring costs that accrue throughout the construction stage). While differences in production costs are insignificant, the authors find that framework-based projects are significantly more cost-effective in terms of transaction costs. Even more specialized models have been developed within the construction domain. For example, (Edwards and Holt, 2011) compare "three types of m-exc stability tests (i.e., tilt, operational, slewing) and contrast these to determine the most reliable testing regime" (Edwards and Holt, 2011, p. 1125). Based on their results, the authors present a mini-excavator procurement model that "incorporates the assessment of machine stability and practical selection criteria" (Edwards and Holt, 2011, p. 1125). To assist decision-makers in choosing between different procurement models, (Cruz and Marques, 2014) have developed a quantitative tool—the Public Sector Comparator—which "allows decision-makers to decide whether the project should be developed along one of two different paths: PPP or traditional procurement" (Cruz and Marques, 2014, p. 122).

Procurement process guidelines

In relation to processes, various procedures and guidelines are suggested in the literature, among these the POISE (Procurement of Information Systems Effectively) procurement process (Feltham, 1995). POISE is described as an innovative procurement process containing guidelines on healthcare information systems purchasing, which require users to specify needs based on local strategies while drawing on a standard core set of system requirements to avoid duplication efforts. In addition, a standardized process provides suppliers with "a familiar documentation framework", which shortens response times. Furthermore, the author recommends using standardized contractual terms and conditions, because they ease discussions with vendors; "standard acceptance criteria, performance guidelines, and risk analysis will all take far less time to negotiate and conclude" (Feltham, 1995, p. 552). Along similar lines, (Alli et al., 2012) investigate the procurement approach used in a South African freeway improvement project in which a standard set of contract documents was

adapted to meet non-standard requirements. Their study suggests that restrictions placed on contractors help ensure that "smaller companies were given opportunities, the monopoly of larger contractors was prevented and the principles of good governance were not compromised" (Alli et al., 2012, p. 17).

The process perspective on IPP also includes studies on the value in fostering a "win-win" environment (Chenggang et al., 2006) and establishing a "two-stage tender" procurement process (Cicmil and Marshall, 2005). (Chenggang et al., 2006) present a partnering process that fosters a "win-win" environment to problem solving and collaboration, and they describe barriers to partnering within the construction industry. Among the barriers mentioned are (1) design and planning barriers; (2) cultural, attitude, and process change barriers; and (3) incentive mechanism barriers. The authors provide recommendations on how to overcome these barriers. (Laryea and Watermeyer, 2014) analyze the successful innovation of the procurement process at Wits University in South Africa. In the process of a large construction initiative, the university decided to use innovative procurement approaches to reduce the difference between expected and achieved outcome of construction projects. They managed to reduce cost overruns to 6 percent. Using document analysis and interviews, the authors identify six steps that were taken to innovate the procurement process: change from a conventional procurement methodology to new engineering contract frameworks; early contractor involvement; enforcement of budgetary discipline; introduction of project management techniques; introduction of health and safety management systems; and close collaboration between the client, design team, and contractor (involving, e.g., shared training). They conclude with recommendations for value-delivery in construction projects, including the set-up of integrated leadership teams with a high level of expertise and a change in the procurement culture "away from traditional procurement cultures and methodologies that tend to be adversarial rather than collaborative" (Laryea and Watermeyer, 2014, p. 230). Based on experiences from another construction project, (Cicmil and Marshall, 2005) analyze the performance of the "two-stage tender" procurement process in terms of project team integration, and the relationships between procurement mechanisms and project team collaboration. "Two-stage tender" refers to a procurement process that is divided into two stages: an early request-for-technical-submission stage and a final design and bidding stage (Cicmil and Marshall, 2005). The authors argue that, in comparison with traditional procurement approaches, this two-stage process allows for better integration of consultants and contractors. (Klingler et al., 2014) look at a major drainage tunnel rehabilitation project in the United States. Traditionally, such projects are often contracted with sole source requirements due to the unique and complex challenges of underground construction. In fear of limited competition and resulting pricing disadvantages, the authors argue that numerous benefits can be achieved by using the "two-stage tender" process. These benefits include better understanding on the part of suppliers of project complexities due to more information sharing at early stages of the process, increased competition, as well as increased innovation and partnering. The paper also accounts for the negative impacts of this innovative procurement process, including the lengthy time needed to request and compare initial bids and proposals, as well as increased complexity and cost of the design stage due to the multiple solutions contained in the proposals, which needed to be integrated. In (Knutsson and Thomasson, 2014), the authors find that a change in the procurement process has a direct effect on the competitive forces in local markets. They look at the case of food procurement in a Swedish municipality and describe how a single manager drives the change from a simple price-oriented food procurement process toward an elaborate

procurement scheme. The authors find that using a more elaborate procurement strategy that includes both financial and non-financial criteria it was possible to stimulate the market and allow for meaningful competition and cooperation among suppliers. An alternative perspective on the procurement process is offered by (Vogel, 2010) who describes the introduction of a new procurement process at NASA that enables operators of large facilities to bring in external funding by allowing external tenants. Using the Michaud Assembly Facility as an example, the author concludes that this procurement scheme can be successfully applied elsewhere (Vogel, 2010).

Information technology

Finally, within the literature there is also an IT perspective on IPP. One article, for example, proposes to customize construction project procurement strategies through a 3-step process based on artificial intelligence (AI) techniques (Lewis et al., 2011). (Johnson and Robinson, 2014) discuss the new trend of governments organizing hackathons—time-limited competitions for prize money by offering public data to app-developers, often with a specific agenda. The authors look at the implications of this new trend in the area of public procurement and civic engagement. It is found that while there is a clear trend of organizing these events, there is of yet no clear understanding of its place in public procurement and its contribution to civic engagement. From the perspective of public procurement, critical issues include low prize money for otherwise cost-intensive IT services and the risk of creating "virtual sweat-shops". Moreover, looking at past experiences with app-development contests, the authors find that many solutions lack long-term applicability and sustainability, which in turn leads to lower future civic engagement and interest.

4.4. Meta-level discussions—public procurement and innovation (PPaI)

In recent years, three articles have been published offering bird's-eye perspectives on public procurement and innovation (Edquist and Zabala-Iturriagoitia, 2012; Hommen and Rolfstam, 2009; Uyarra and Flanagan, 2010). These articles add insights into how innovation influences public procurement practices, and they provide meta-level discussions across categories and industries. All three articles propose taxonomies or frameworks that classify and structure the field. Two articles include qualitative empirical evidence (Edquist and Zabala-Iturriagoitia, 2012; Hommen and Rolfstam, 2009) while one study is purely theoretical in nature (Uyarra and Flanagan, 2010).

Hommen & Rolfstam (2009) propose a taxonomy for specifying the relationship between public procurement and innovation based on "the interaction of users and producers and the evolution of technologies and markets" (p. 19). The authors present a review of interaction theory literature and evolution theory. Categorizing PPfI as direct, cooperative, and catalytic procurement, the article presents multiple dimensions for each category (mode of interaction, public vs. private demand, public intervention rationales, type of innovative activity, and characteristic modalities). Moreover, they empirically test their framework through 14 exploratory case studies from two different EU research projects and find that the distinction between direct, co-operative, and catalytic procurement proves useful to practitioners.

Similarly, Uyarra & Flanagan (2010) present an overview of different conceptualizations of public procurement and innovation. They argue that the existing knowledge of the complexity of innovation paths is limited and

current research does not address the heterogeneity of the field. However, rather than referring to specific types of procurement, the authors promote the use of "innovation friendly" procurement practices as a collective term referring to innovation effects across all types and levels of procurement. Their analysis of innovation routes leads to a product-based typology that helps public employees "better understand the possibilities and limits of government action with regard to the promotion of innovation through public procurement" (Uyarra and Flanagan, 2010, p. 140). The authors conclude with a call for others to empirically test the proposed theoretical framework.

Edquist & Zabala-Iturriagoitia (2012) discuss how to use innovative public procurement to solve so-called "grand challenges" by targeting procurement activities. The authors describe six case studies that are categorized according to type of procurement, e.g. type of buyer and supplier. The authors demonstrate through examples how PPAI can contribute to solving big problems and suggest that policies should be adapted to realize the innovation potential of procurement. In addition to classifying procurement types and strategies for public-private cooperation, the six cases are analyzed in detail according to societal challenges, results, and unintended consequences of procurement. In terms of implications, the authors describe how to change traditional procurement into innovation-oriented procurement practices. They state that strategy changes are needed both at the level of individuals and organizations and that "the procurement of existing products should be partly replaced by the procurement of results in terms of societal problem solving and needs' satisfaction" (Edquist and Zabala-Iturriagoitia, 2012, p. 1768).

Although the three articles engage in meta-level discussions of procurement as an innovation driver (Hommen and Rolfstam, 2009; Uyarra and Flanagan, 2010) and a means to problem solving (Edquist and Zabala-Iturriagoitia, 2012), none of them offer a unified terminology and holistic understanding of the concepts involved in public procurement and innovation, which is what this article aims to contribute.

4.5. Relationships among core streams

The systematic review and analysis of the literature on innovation in public procurement forms the basis for categorization of contributions according to common themes and topics that emerge from the bottom up. In addition, a few articles discuss the topic of public procurement and innovation (PPAI) at an abstract level with the purpose of characterizing the field, identifying trends, providing new perspectives, and suggesting avenues for future research and practice. Figure 3 illustrates the relationship between research streams and topics found in the literature.

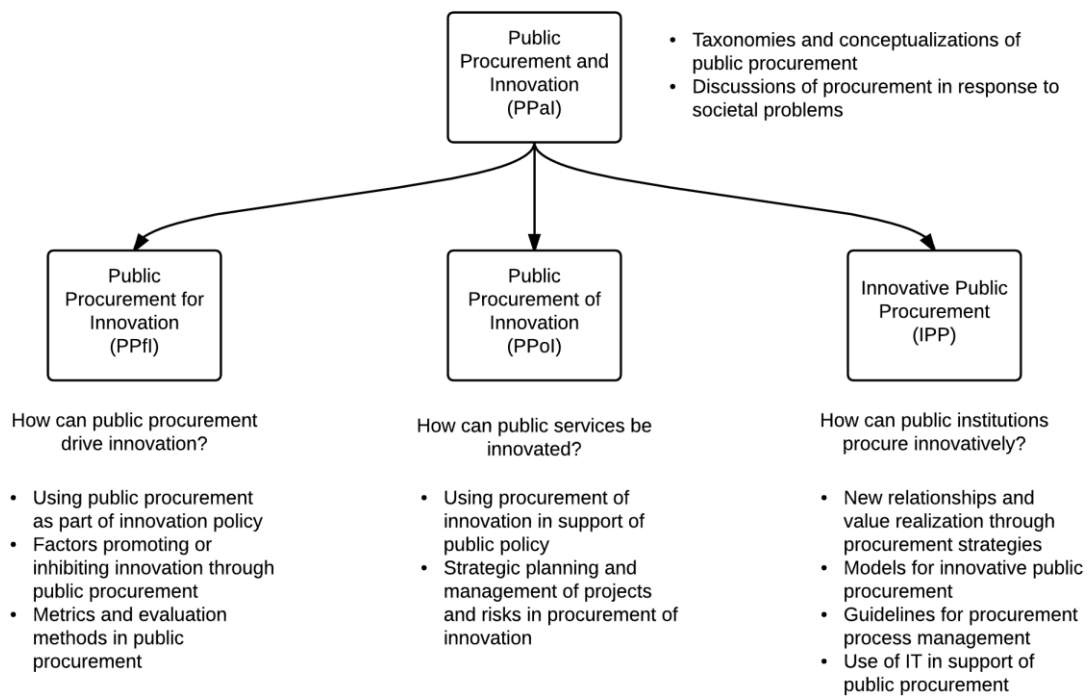


Figure 3: Research streams and topics

The synthesis of extant research shows that most papers fall within one of three streams with regard to the motivation behind the studies. However, these streams are not mutually exclusive and in many cases interrelated. Many articles discuss topics such as methods, processes, and results crossing the boundaries between streams. This high degree of interconnectedness can be attributed to two characteristics of the field and its current state:

First, blurry conceptual boundaries are to be expected when engaging in interdisciplinary research within an emerging field of study (Ågerfalk and Fitzgerald, 2006). The streams and topics (i.e. the categories) are interrelated and difficult to separate. PPoI, for example, is likely to positively influence PPfI, in the sense that rethinking public services requires (and therefore stimulates) the creation of innovative products and services on the market (Yeow and Edler, 2012). Similarly, new management approaches that are prerequisites for efficient PPoI—including methods for evaluating outcome and success—will likely draw on IPP methods (Stillesjoe, 1993).

Second, while both research and practice are often motivated by specific goals, innovation within academia as well as practice tends to create spillover effects beyond the original scope. This is a well-known phenomenon among innovation scholars in general (Cohen and Levinthal, 1989) and procurement researchers in particular (Edler & Georghiou, 2007; Uyerra & Flanagan, 2010), which makes it difficult for researchers and practitioners alike to evaluate innovation outcomes.

4.6. Theoretical foundation of existing research

Innovation in public procurement is an interdisciplinary field of study. The existing literature draws on procurement as well as innovation research, which is evidenced in the diversity of theoretical perspectives that are employed. Yet, the number of articles explicitly relying on particular theoretical frameworks is low. This review reveals the use of institutional and innovation theory, systems theory, as well as transaction cost economics and risk management theories.

In their theoretical work, Edquist & Hommen (1999) analyze and discuss the applicability of institutional theory (Scott, 2008) among others (systems theory, interactive learning theory, and evolutionary learning theory) to support policy making in PPfI. Based on their work, other researchers have used institutional theory to investigate the organizational and structural challenges in using public procurement as part of innovation policies (Rolfstam, 2012a, 2012b, 2009; Rolfstam et al., 2011). In the context of PPfI, institutional theory proves to be a helpful lens in identifying relevant institutions, actors, and their roles in changing public procurement activities to foster innovative markets. Moreover, due to the complexity of the innovation and public procurement environment with its numerous organizational, technological, and legal constraints, institutional theory provides a useful analytical perspective in trying to understand the mechanisms and principles at work, and "how these rules may affect the possibilities for public agencies to procure innovation" (Rolfstam, 2009, p. 349). All of the reviewed papers are, however, descriptive case studies, which limits the generalizability and applicability of the findings in different contexts. This is particularly important in the context of PPfI, as the legal and cultural contexts as well as local institutions and policies influence the success of innovation efforts.

From an IPP perspective, (Pena-Mora and Harpoth, 2001) apply a system dynamics (Forrester, 1971) perspective to analyze and model the interdependencies and variables influencing behavior in public construction projects. They find that modeling the procurement process and its dynamics in such detail is helpful to identify the strengths and weaknesses in often complex systems. (Boes and Dorée, 2011) use transaction cost economics in framing their analysis of Dutch highway procurement projects. They demonstrate the usefulness of this perspective in analyzing data from different projects and showing why a shift in competition based on price toward quality is unlikely.

For the purpose of analyzing strategic risks and inferring lessons learned from different cases of PPOI in Baltic cities, (Kalvet and Lember, 2010) utilize risk management theories to inform their research. They find that many cities lack the ability to manage the risks involved in procurement of innovation properly and thus need to invest in developing the necessary skills for efficient PPOI.

The diversity of theoretical perspectives coupled with low number of articles that rely on theoretical frameworks is a testament to the immaturity of the research field. Furthermore, researchers' use of theory for understanding needs to be translated into practitioner-oriented guidelines for innovation in public procurement.

4.7. The concept of innovation in the literature

After having analyzed the literature, it is apparent that the majority of articles avoid defining let alone discussing the concept of innovation. Without explicating it, most articles use "innovation" and "innovative" to

describe solutions to problems or responding to demands in a new, improved, or non-traditional way. In many cases, the authors simply describe a new method or product as "innovative" (see, e.g., Kashiwagi, 2002) without further elaboration. The lack of a common vocabulary is a problem for both researchers and practitioners. First, researchers may find it difficult to identify and extend existing knowledge when concepts are not clearly defined and a common terminology is absent. Second, practitioners and policymakers confront operational and legal risks in procurement projects when consensus and transparency regarding definitions of innovation and innovativeness are lacking (Rolfstam, 2012b). In line with prior research, this study finds that commonly used definitions of innovation fail to account for the multi-faceted nature of the concept, in particular with regard to emergent and spillover effects of innovative behavior (Uyarra and Flanagan, 2010).

Among those authors who actively define innovation in their publications, a number of different ideas and concepts circulate. In the following, an overview of these definitions is provided in support of a synthesized understanding. Conceptualizations of innovation in public procurement can be viewed from three different perspectives: traditional versus innovative procurement, innovation versus diffusion, and product versus process innovation.

Traditional versus innovative procurement

The Oslo Manual, issued by the Organization for Economic Co-operation and Development (OECD) in 2005 (OECD, 2005), defines innovation as the "implementation of a new or significantly improved product (good or service), or process, or marketing method, or a new organization method in business practices, workplace organization or external relations" (OECD, 2005, p. 46). This definition is adopted by some authors (Kalvet, 2012; Kalvet and Lember, 2010; Lember et al., 2010). In comparison, the articles by (Borrás and Edquist, 2013; Edquist and Zabala-Iturriagoitia, 2014, 2012) are based on the definition of innovation as "creations of economic and societal influence", including both product (goods or intangibles) and process (technological or organizational) innovations. This definition stresses the fact that the innovation needs to be commercialized and thereby have an economic or social impact in order to qualify as an innovation.

An analysis of how existing research conceptualizes innovation reveals that there is a certain degree of ambiguity present. In (Georghiou et al., 2014, p. 2), public procurement of innovation is defined in the form of public purchasers "demanding goods or services that do yet exist". However, this narrow definition is more applicable to the concept of pre-commercial procurement (PCP). PCP, in contrast to general procurement of innovation, emphasizes the need for new development of a solution to solve a specific requirement. As discussed in the following subsection, procurement of innovation does not necessarily require a new development, but can also refer to the dissemination of existing products or services to new areas or applications. This ambiguity of definitions supports the argument that a clear separation of concepts is yet to be established. (Georghiou et al., 2014, p. 2) elaborate on their perspective by stating that "fundamental innovation-related activity comes when a public purchaser, in making its choice of what to buy, either seeks to trigger innovation by demanding goods or services that do yet exist, or responds to it by favouring goods or services which have innovative characteristics." As an example of a more broad understanding of procurement of innovation, (Rolfstam, 2012b, p. 113) bases his categorization of a project for the construction of a power plant on Schumpeter (Schumpeter, 1934) and argues that it is innovative since "it involved, at least on the

national level, the introduction of a new good, a new method of production, it would have opened up a local market for fast-cropping timber and, consequently, it would have meant the creation of demand for new raw materials."

Furthermore, a number of articles discuss the distinction between regular or traditional procurement and innovative procurement (see, e.g., Edquist et al., 2000; Uyarra and Flanagan, 2010). An in-depth discussion of the differences between regular and innovative procurement is found in (Hommen and Rolfstam, 2009). The authors state that "in order to affect innovation, public procurement must influence either or both the direction and rate of technological change" (Hommen and Rolfstam, 2009, p. 20). In continuation hereof, procurement of innovation is defined as "the purchase, by government or public sector organizations of products that are innovative, or 'new', in Schumpeter's sense, and whose development typically involves significant R&D expenditure" (Hommen and Rolfstam, 2009, p. 21). In the particular context of construction projects, (Lu et al., 2013) state that innovative public procurement is the use of "new methods to acquire project resources such as finance, technical skills, materials, labor, and professional services for the realization of a constructed facility" (Lu et al., 2013, p. 348). The authors are aware, however, that innovative procurement means different things to different people—both researchers and practitioners.

As a first step towards consolidating conflicting views and definitions, (Uyarra and Flanagan, 2010) argue against the conceptual distinction between traditional and innovative procurement but suggest "a broader interpretation that recognizes that public procurement serves specific public needs and that innovation should be encouraged, where possible, as a 'by-product' of the procurement process" (Uyarra and Flanagan, 2010, p. 129). Along the same lines, (Vecchiato and Roveda, 2014, p. 440) define the need of public institutions for something that "cannot be met from off-the-shelf goods or services and hence that an innovation is required to meet the demand" as the basis for innovation in public procurement. Such broad perspectives may be helpful in understanding the enormous potential for innovation in procurement, but are limited in terms of measurability and comparability. Thus, policymakers and public procurement agencies may find it difficult to apply these broad conceptualizations, while at the same time being held accountable for clear and transparent decision processes.

Innovation versus diffusion and adoption

The literature on PPal is in many respects ambiguous in terms of whether innovation relates to the creation of something new or the diffusion of something existing into new places (where it has not been used before). On the one hand, innovations may be the result of developing new products or solutions, i.e., something that did not exist before. For example, the development and commercialization of new battery technology (for use in, e.g., hybrid cars) was an innovation in its own time, because the technology did not exist before. On the other hand, innovations may be construed as something that is new to particular settings, e.g. technology being diffused across additional countries while already being in use in others. The implementation of IP telephony in an organization is an example of diffusion and adoption, since this technology is already used in other organizations although it may be considered innovative by the larger population of organizations.

Similarly, (Knutsson and Thomasson, 2014, p. 245) argue that "innovation does not have to be a new technology or something completely new. It can be a new way of doing things or about spreading and adopting new ideas." In addition, (Uyarra and Flanagan, 2010) draw on the definition by (Edquist et al., 2000) and differentiate between developmental procurement, which is synonymous with creating new products, processes, or systems, and adaptive procurement, which denotes the diffusion of existing solutions into new domains or locations (e.g. countries or organizations). Likewise, (Rolfstam et al., 2011; Yeow and Edler, 2012) base their understanding on the conceptualization of innovation proposed by (Edquist and Zabala-Iturriagaitia, 2012), i.e. that innovations are both new developments and the diffusion and adoption of existing solutions. This conceptual ambiguity is not only interesting from an academic perspective, it also poses challenges for practitioners in planning, monitoring, and evaluating innovation efforts.

Product versus process innovation

There is general agreement among researchers regarding the distinction between product innovation (innovative products and services) and process innovation (Aschhoff and Sofka, 2009; Knutsson and Thomasson, 2014; Uyarra and Flanagan, 2010). Based on Schumpeter's seminal work on innovation (Schumpeter, 1934), Hommen & Rolfstam (2009) also distinguish between product and process innovation, and use it to separate "procurement of innovations" (including both PPOI and PPFI in the proposed terminology) from "innovations in procurement" (IPP). Rullan et al. (2012, p. 559) challenge this dichotomous distinction between process and product and argue for "a broad concept of innovation that includes not only the product, but also process, business model, design, marketing and branding, services, social, and organizational."

In general, the existing literature relates public procurement to established innovation concepts, such as process and product innovation, but tries to broaden the perspective on innovation in public procurement to accommodate a wider conceptualization. One specific example of this is given in (Goodchild and Chamberlain, 1999), who discuss innovation in construction as design and product innovation, while it can also "mean a process which leads in completely new and untried directions" (Goodchild and Chamberlain, 1999, p. 875). The authors are among the few researchers who discuss potential negative effects of innovation and state that too much innovation or ill-conceived innovation increases the risk of cost overruns and lower quality. Innovation and its associated benefits have to be "balanced against the need of the client to maintain control and to insist on proven techniques and materials" (Goodchild and Chamberlain, 1999, p. 877). These different perspectives on innovation (e.g. innovation versus diffusion and adopting and product versus process innovation) underscore the need for a unified terminology and holistic understanding of innovation in public procurement, as offered by the framework proposed by this study.

5. Implications and future research [Directions]

This article builds on a systematic and comprehensive review of the literature to provide insights into the nature of current research on innovation in public procurement. Based on our findings and ongoing developments in the field, the following chapters present the strengths and weaknesses of current state-of-the-art knowledge, point to knowledge gaps, and suggest avenues for future research.

5.1. Integration of existing literature streams

This research reveals three conceptually related but largely disconnected research streams within the area of innovation in public procurement. This is attributable to the interdisciplinary nature of the field, attracting multidisciplinary research across innovation management, public administration, and procurement. While such diversity with regard to reference disciplines is an asset, most studies do not capitalize on it by drawing on theories and perspectives across disciplinary boundaries. The vast majority of IPP studies do not discuss the impact on the broader context of developing and introducing innovative procurement processes, thereby ignoring both potentially positive and negative side-effects that might arise as a result. For example, (Witteveen and Doree, 2011) describe the introduction of a new procurement scheme by the Dutch Highway Authority as successful since it had "a positive impact on time, budget, quality and client satisfaction". However, the likely positive effects of the new process of stimulating the innovation capabilities of suppliers (PPfl) or renewing the public infrastructure (PPol) are largely ignored in the study. Overall, the identified literature streams are to a great extent disconnected and often fail to incorporate insights from adjacent streams. Moreover, the conceptual interconnectedness across the different disciplines as well as the ambiguity of key concepts in the field prevent researchers from systematically advancing state-of-the-art knowledge of innovation in public procurement.

To alleviate this problem, and in order to better understand the role of innovation in public procurement, there is a need for greater integration across streams, ultimately leading to greater conceptual clarity and comparability of empirical constructs. This would provide a firmer basis on which future research can be based for the purpose of analyzing, understanding, and theorizing innovative behavior as it relates to public procurement. Toward that end, this article provides an overview of the existing literature through a framework of research streams and topics, clarifies terminology, defines key concepts, guides researchers and practitioners to relevant knowledge, and helps set a research agenda for the future. The framework is both a point of departure for future research and a source of knowledge for practitioners. Researchers may draw upon this review to identify avenues for research. For example, the scarcity of meta-level contributions, including theories and discussions of a conceptual nature, underscores that much academic work is needed to catch up with the reality of procurement practices within the public sector and to provide practitioners and policymakers with relevant and up-to-date knowledge. Practitioners may use the framework and the accompanying overview of the literature to identify sources of knowledge that can inform policies, strategies, and projects on innovation in public procurement. For example, Table 1 contains references to articles on impact analysis in PPfl. This information is valuable if faced with the challenge of selecting or establishing metrics and evaluation methods for the purpose of determining the impact of public procurement in promoting innovation (Figure 3).

5.2. Theoretical frames and methodological diversity

A large majority of PPfl articles are grounded in the innovation literature and are therefore informed by concepts and ideas from this body of knowledge, which draws heavily on institutional and organizational theory. In contrast, most IPP and PPol articles lack a theoretical backbone and present primarily descriptive analyses of cases with little or no theoretical contribution. This calls for more theory-based studies in order to

mature and advance the current knowledge base of innovation in public procurement. The interdisciplinary nature of the field provides ample opportunities for both relevant and rigorous research.

In the area of IPP, many articles describe strategic or operational models to support the process of innovative public procurement. However, since their theoretical foundation is weak, the contribution is primarily empirical in nature and difficult to generalize beyond the specific context. In the Information Systems research field, the difficulty of using theoretical frameworks in practical problem solving has led to the widespread acceptance of design theories (Hevner et al., 2004; March and Smith, 1995; Peffers et al., 2007a). In particular, studies that seek to develop specific models (e.g., Cruz and Marques, 2014; Edwards and Holt, 2011) or processes (e.g., Feltham, 1995) would benefit from following a structured design approach as proposed by (Offermann et al., 2009; Peffers et al., 2007b), which would allow the authors to elevate their contribution from systems building to actual process and design guidelines that can inform both practitioners and future research.

From a research perspective, much knowledge on public procurement can be found within the Supply Chain Management (SCM) literature. However, the theoretical foundation of much SCM research—the Resource-Based View (RBV)—has not yet been utilized in the area of innovation in public procurement (Hitt et al., 2016). In particular, the extended perspectives on RBV, e.g. the knowledge-based view, the concept of absorptive capacity (Zahra and George, 2002), and the dynamic capabilities perspective (Teece and Gary, 1997), hold great potential in supporting scholars investigating structures within this complex and dynamic research field.

From a methodological standpoint, this review shows that qualitative case studies are preferred as a research approach. Out of 42 studies based on empirical data, only 15 apply quantitative methods. While qualitative case study research provides valuable insights, it has limitations in terms of generalization and robustness (Eisenhardt, 1989; Lee and Baskerville, 2003). In line with (Georghiou et al., 2014; Peng and Cai, 2008), who point to the need for new measurement and evaluation models for public procurement, this study confirms that practitioners need tangible and generalizable results based on robust data to support policy- and decision-making. Large-scale surveys of supplier-buyer relationships as well as statistical data from national or supranational institutions can provide a firm basis for further investigations and analyses, as is demonstrated by the few articles based on a quantitative research design (see, e.g., Georghiou et al., 2014; Guerzoni & Raiteri, 2015; Rullan et al., 2012). Research using quantitative methods in support of decision processes in practice may provide decision-makers with valuable knowledge when considering procurement of innovative solutions to public sector problems, especially in times of strained public budgets and risk averse procurement policies.

5.3. Managerial practice and relevance

Depending on the type and conceptualization of innovation in public procurement (see discussion above), procurement practitioners are challenged with a need for new and improved management skills (Boes and Dorée, 2008; Yeow and Edler, 2012). This is particularly relevant for projects that require involvement of procurement personnel in R&D management, as for example in PCP projects. Successful procurement of innovation requires that "better links between the procurement function and the research and development (R&D) function" (Georghiou et al., 2014, p. 2) be created.

With a perspective on stimulating and managing R&D at the national level, Geroski (1990) concludes that public procurement policy is the most effective demand-side instrument in nurturing development early the product life-cycle, because this is the stage where technological advances are made but where there is no demand. Companies innovation capability and their R&D efforts are strengthened as an effect of governments' innovation policy (Peng and Cai, 2008). Aschhoff and Sofka (2009) furthermore demonstrate a positive effect on market success. "Governments should develop long-term policies to help firms in their efforts ranging from R&D, prototype development and testing to market launch", however, "for firms to engage in technology development, continuity in technology policy is necessary" (Caerteling et al., 2009, p. 1217). Moreover, on the side of the suppliers, the authors suggest that "firms should invest in relationships with champions within government. ... Professional ties between firms and government are more likely to have a positive effect on firm performance" (Caerteling et al., 2009, p. 1217).

However, research on PPol only accounts for the smallest part of the surveyed literature, with eight out of 66 articles belonging to this stream of research. Topics within PPol—such as organizational change strategies and innovation management approaches—are closely related to practitioners' everyday practices and should therefore also be of interest to researchers. The lack of such studies thus confirms prior observations that point to a lack of management perspectives in the literature (Valovirta, 2012, p. 6). As a consequence, Rolfstam (2012a) remarks that "the old efficiency-policies have for many years affected practice, leading to procurers developing risk-averse behavior", reducing willingness and incentives to launch innovation projects. Other researchers have pointed out that all areas of innovation in public procurement require new management skills and changes in procurement strategy, away from traditionally risk averse public procurement toward long-term planning and risk management approaches to procurement (Boes and Dorée, 2008; Kalvet and Lember, 2010; Klingler et al., 2014; Lember et al., 2015). While practitioners often demonstrate good intentions and strive to be innovative in their procurement activities, the lack of academic insights and practical guidance increases the risk of getting "caught in debates over accountability, legitimacy and integrity" (Boes and Dorée, 2008, p. 8). In addition, political reports and ideologies are powerful forces working to sustain the status quo of price-focused procurement practices over value-based approaches (Meehan et al., 2017). The inherently complex nature of innovative procurement compared to traditional procurement calls for an increased focus on project management instead of routine day-to-day procurement practices (Yeow and Edler, 2012).

In line with these findings, Rolfstam (2012a) points out that academic research fails to catch up with the "almost exponentially increasing interest" among policymakers. In addition, this review shows that more research from a managerial perspective is necessary to close the existing gap between academia and practice and may lead to tangible insights that can guide managerial practice of R&D and innovation projects within the realm of public procurement.

5.4. Buyer vs. supplier perspective

Most of the literature is written from the buyer perspective on public procurement projects (e.g. municipalities, cities, and governments). Little research has yet investigated the supplier side, although some promising avenues for future research can be identified (Uyarra et al., 2014). Particularly relevant for policy makers and practitioners, studies show that certain characteristics of suppliers, such as size or non-profit

orientation, may lead to low participation in tenders and subsequent disadvantages in the procurement process (Flynn, 2017; Flynn et al., 2015; Uyarra et al., 2014).

Policy initiatives to foster SME participation need to be carefully planned and tested, as they might otherwise be counterproductive. For example, while the European Union encourages the use of MEAT (Most Economically Advantageous Tender) over traditional lowest price tenders, arguing that it stimulates SMEs participation, (Stake, 2017) presents contradictory empirical evidence and argues that MEAT in fact increases the participation of large firms and is thus counterproductive. Moreover, a plethora of factors may impede or outright work against initiatives to increase SME participation, such as lack of commitment, competing political agendas, or the presence of risk averse cultures (Davis and Brady, 2015). However, (Reijonen et al., 2016) show that the degree of SME participation in public tenders is also related to their degree of entrepreneurial orientation, i.e. how actively an SME participates in searching for tenders and submitting bids. With regard to designing "SME-friendly" tenders, (Timmermans and Zabala-Iturriagoitia, 2013) propose a so-called "coordinated unbundling" approach, aiming to break down large public procurement tenders into smaller parts in order to stimulate participation of small and medium sized suppliers. Interestingly, from a supplier perspective, SME's innovation performance is also influenced by their participation in networks with other firms, helping to overcome disadvantages in terms of resources and capabilities that hinder small firm participation in large public tenders (Saastamoinen et al., 2018).

In relation to roles of buyers and suppliers, (Caloffi and Gambarotto, 2017; Edler and Yeow, 2016; Landoni, 2017) add a third perspective and focus on the role of institutional intermediaries in the procurement of innovation (Howells, 2006). Such intermediaries may prove helpful in building bridges between the actors involved, but more work is needed to better understand the "conditions that determine the effectiveness of intermediation between demand and supply of innovation" (Edler and Yeow, 2016, p. 424).

Overall, the analysis reveals that the complex dynamics between buyers, supplier, and intermediaries are currently under-researched, and future research may help to understand the needs of the market for, and the effects of, innovative procurement practices.

5.5. Technological change as a driver for new procurement routes

The pace of technological development and the unpredictable impact of new and disruptive models challenge policy-makers and procurement practitioners. In general, the literature shows that researchers are increasingly aware of the widespread interest in the adoption of e-procurement initiatives in different countries (Caloghirou et al., 2016; Svidronova and Mikus, 2015), and recent studies provide valuable insights into the potential benefits and risks of such initiatives (Barahona et al., 2015; Haim Faridian, 2015). As a radical change to the procurement process, Johnson and Robinson (2014) investigate hackathons as a concept used in public procurement. Hackathons are time-limited events that offer participants monetary and other rewards for delivering IT solutions based on, e.g., open government data (Hartmann et al., 2016). While such new experiments hold great potential for fostering innovation, they may be used as "back-door" alternatives to traditional procurement routes, thereby circumventing public procurement policies and rules (e.g. regulations regarding openness, transparency etc.) (Johnson and Robinson, 2014). Utilizing recent technological

advancements, Lewis et al. (2011) propose the use of AI techniques to customize procurement strategies. Hackathons and AI techniques, which are part of larger social and technological trends, may have potential for application to different areas of PPAI, but research into proper management and utilization of these is currently lacking. Johnson and Robinson (2014) emphasize some problems, such as lack of legislation, vague terminology, and ethical issues, related to these procurement techniques. However, a number of recent initiatives aim to foster increased use of open government data in short-time innovation contests, such as the Open Data Day (Open Data Day, 2017), the international Open Government Partnership (Open Government Partnership, 2017), or the Open Government Data Platform (Open Government Data Platform India, 2017). They are furthermore indicative of the fast-paced developments within this field. Some of the success stories resulting from using this innovative form of public procurement include smart energy and mobility solutions (Ceehacks, 2017) as well as government transparency solutions (Transparency International, 2013). In this light, additional developments can be expected soon and researchers should see them as opportunities for engagement and investigation in their attempts to provide scientifically sound guidance to practitioners.

6. Conclusions

In this article, a review of the literature on innovation in public procurement is presented. Across the 66 articles reviewed, three literature streams are identified: (1), public procurement for innovation (PPFI), (2) public procurement of innovations (PPOI), and (3) innovative public procurement (IPP). In addition, three articles transcend these categories by engaging in meta-level discussions of the concept of public procurement and innovation (PPAI). The analysis of the literature reveals nine recurring themes or topics across the literature streams, and the article provides an overview of state-of-the-art knowledge of each topic, which is synthesized into a framework of innovation in public procurement. The framework offers a unified terminology and holistic understanding of innovation in public procurement, which is both a point of departure for future research and a source of knowledge for practitioners. The ensuing discussion focuses on the conceptualizations of innovation based on distinctions between traditional versus innovative procurement, innovation versus diffusion and adoption, and product versus process innovation. To support future research endeavors within innovation in public procurement, five concrete areas of improvement have been identified: the integration of existing research to ensure greater conceptual clarity and comparability, the need for more theory-based studies, closing the gap between existing research and procurement practices, remedying the scarcity of research on innovation in public procurement from a supplier perspective, and addressing the lack of knowledge of IT as a lever for innovation in public procurement.

This study was conducted with certain limitations. As is the case with any literature review spanning several research streams, there is a risk of overlooking relevant articles despite having followed a systematic and rigorous search and selection process. To mitigate this risk, future research should include additional scientific databases and practitioner-oriented publication outlets, which would also serve to complement the findings of this study. This study presents a conceptual model developed on the basis of the literature review, but at the time of writing it lacks empirical validation. Further investigations should include expert panels with researchers and practitioners to validate and potentially augment the proposed framework.

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Appendix A

Table A.1 displays the categorization of articles using key codes from the coding scheme developed.

Article	Outlet	Type	Empirical data	Domain	Region
Alli et al. 2012	Proceedings of the ICE - Management, Procurement and Law	IPP		Construction	South Africa
Aschhoff et al. 2009	Research Policy	PPfl	Quantitative		Germany
Boes et al. 2008	ARCOM Conference	IPP	Mixed	Construction	Netherlands
Boes et al. 2011	ARCOM Conference	IPP	Quantitative	Construction	Netherlands
Borras et al. 2013	Technological forecast and social change	PPfl			
Caerteling et al. 2009	Journal of Construction Engineering and Management	PPfl	Quantitative	Construction	USA
Caldwell et al. 2005	Journal of Purchasing and Supply Management	PPfl	Qualitative	Multiple	UK
Carpintero et al. 2009	WIT Transactions on Ecology and the Environment	IPP		Infrastructure	Madrid
Chenggang et al. 2006	Proceedings of the 2006 International Conference on Construction & Real Estate Management	IPP		Construction	
Cicmil et al. 2005	Building Research and Information	IPP	Qualitative	Construction	
Cruz et al. 2014	Journal of Management in Engineering	IPP	Quantitative	Healthcare	
Dalpe 1994	Technology in Society	PPfl			
Dalpe et al. 1992	Research Policy	PPfl	Quantitative		Canada
Eadie et al. 2013	International Journal of Procurement Management	IPP	Quantitative		Ireland
Edler et al. 2007	Research Policy	PPfl			EU
Edler et al. 2012	Research Evaluation	PPfl			EU
Edquist et al. 1999	Technology in Society	PPfl			
Edquist et al. 2012	Research Policy	PPal	Qualitative		Sweden, Norway, USA
Edquist et al. 2014	R&D Management	PPfl	Qualitative	Multiple	Netherlands, UK, Australia
Edwards et al. 2011	Journal of Construction Engineering and Management	IPP		Construction	
Feltham 1995	MEDINFO 95 Proceedings	IPP		Healthcare	UK
Gee et al. 2013	Technology Analysis and Strategic Management	PPol	Qualitative	Infrastructure	UK
Georghiou et al. 2014	Technological forecast and social change	PPfl	Quantitative		UK

Geroski 1990	International Review of Applied Economics	PPfl			
Gianakis et al. 2012	Journal of Public Procurement	PPol	Qualitative		USA
Goodchild et al. 1999	Housing Studies	IPP		Construction	UK
Guerzoni et al. 2015	Research Policy	PPfl	Quantitative		EU
Hommen et al. 2009	Journal of Public Procurement	PPal	Qualitative		EU
Jeffcoat et al. 2005	American Water Works Association Annual Conference	IPP		Construction	USA
Johnson et al. 2014	Review of Policy Research	IPP		App-development	
Kalvet 2012	International Journal of Electronic Government	PPol			Estonia
Kalvet et al. 2010	Innovation: The European Journal of Social Science Research	PPol	Qualitative	Multiple	Baltic Sea Region
Kashiwagi 2002	Cost Engineering	IPP	Quantitative	Construction	USA
Kashiwagi et al. 2004	ARCOM Conference	IPP	Quantitative	Construction	USA
Keating et al. 1986	Journal of Healthcare Material Management	IPP		Healthcare	USA
Khalfan et al. 2011	Malaysian Construction Research Journal	IPP	Mixed	Construction	UK
Khalfan et al. 2008	Journal of King Abdul Aziz University: Engineering Science	IPP	Qualitative	Construction	UK
Klingler et al. 2014	North American Tunneling 2014 Proceedings	IPP	Qualitative	Construction	USA
Knutsson et al. 2014	Public Management Review	IPP	Qualitative	Food	Sweden
Lam et al. 2014	Construction Management and Economics	IPP	Mixed	Construction	UK
Laryea et al. 2014	Management, Procurement and Law	IPP	Qualitative	Construction	South Africa
Lember et al. 2011	Urban Studies	PPfl	Qualitative		Baltic Sea Region
Lewis et al. 2011	ARCOM Conference	IPP		Construction	UK
Liu et al. 2011	Construction Innovation	IPP	Qualitative	Construction	New Zealand
Lu et al. 2013	Journal of Construction Engineering and Management	IPP	Qualitative	Construction	China
Manase et al. 2011	COBRA 2011 Proceedings of RICS Construction and Property Conference	IPP	Qualitative	Construction	UK
Myoken 2010	International Journal of Technology Management	PPfl			Japan, US
Nilsson 1991	International Energy Conference on Demand-Side Management: A Current And Future Resource	PPol		Energy	Sweden

Peña-Mora et al. 2001	Journal of Management in Engineering	IPP	Qualitative	Construction	Puerto Rico
Peng et al. 2008	International Conference on Management Science & Engineering	PPfl			China
Phillips et al. 2007	Health Policy	PPfl	Qualitative	Healthcare	UK
Pryke 2006	Journal of Professional Issues in Engineering Education and Practice	IPP	Qualitative	Construction	UK
Rolfstam 2012	Haliduskultuur - Administrative Culture	PPfl	Qualitative	Energy	UK
Rolfstam 2012	Innovation: The European Journal of Social Science Research	PPfl			EU
Rolfstam 2009	Science and Public Policy	PPfl			Norway, UK
Rolfstam et al. 2011	International Journal of Public Sector Management	PPfl	Qualitative	Healthcare	UK
Rullan et al. 2012	Proceedings of the 2012 IEEE ISMOT	PPfl	Quantitative		Latin America
Stillesjø 1993	Energy	PPol	Qualitative	Facility Mgmt	Sweden
Timmermanns et al. 2013	Science and Public Policy	PPfl			EU
Uyarra et al. 2010	European Planning Studies	PPal			
Uyarra et al. 2014	Technovation	PPfl	Quantitative		UK
Valovirta 2012	'Demand, Innovation and Policy' conference	PPol	Qualitative		Finland
Vecchiato et al. 2014	Research Policy	PPfl	Qualitative	Multiple	Lombardy
Vogel 2010	AIAA Space Conference	IPP	Qualitative	Aerospace	USA
Witteveen et al. 2011	ARCOM Conference	IPP	Qualitative	Construction	Netherlands
Yeow et al. 2012	Journal of Public Procurement	PPol	Qualitative	Healthcare	UK

Table A.1: Categorization of articles using select codes