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The Innovative Public Procurer: A taxonomy of government organizations across Europe valuing innovative criteria in their purchasing

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Abstract

Policy has opened public procurement to innovation by promoting the use of innovative criteria to determine the most economically advantageous tender, supporting best price-quality ratios in award criteria. However, cost predominantly remains the deciding factor in procurement across Europe. To maximize impacts of public purchasing on markets, the pre-procurement consultation process is critical. As an exploratory analysis, this paper develops a taxonomy from 920 innovative procurers across Europe using cluster analyses to identify the types of organizations recognizing these policies, in terms of innovation profiles, information sourcing, tendering area, and organizational characteristics. Three types of innovative procuring organization are identified: 1) Large collaborative procurers practicing Public Procurement of Innovation and organizational innovation (30.1%); 2) Supplier-focused Pre-Commercial Procurers, strong in service innovation by outsourcing (25.4%); and 3) Independent, infrequent direct procurers at the local level (44.5%). Findings suggest that innovative procurement may be at odds with New Public Management approaches to public services, and resources for collaboration and policy drivers appear most recognized at regional and national-level organizations. More focus is required to assist smaller, local organizations that constitute the majority of procurers valuing innovation in tender award criteria to better leverage its potential.

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Policy has opened public procurement to innovation by promoting the use of innovative criteria to determine the most economically advantageous tender, supporting best price-quality ratios in award criteria. However, cost predominantly remains the deciding factor in procurement across Europe. To maximize impacts of public purchasing on markets, the examining implementation of innovative criteria through pre-procurement consultation process is critical. As an exploratory analysis, this paper develops a taxonomy from 920 innovative procurers across Europe using cluster analyses to identify the types of organizations recognizing these policies, in terms of innovation profiles, information sourcing, tendering area, and organizational characteristics. Three types of innovative procuring organization are identified: 1) Large collaborative procurers practicing Public Procurement of Innovation and organizational innovation (30.1%); 2) Supplier-focused Pre-Commercial Procurers, strong in service innovation by outsourcing (25.4%); and 3) Independent, infrequent direct procurers at the local level (44.5%). Findings suggest that innovative procurement may be at odds with New Public Management approaches to public services, and resources for collaboration and policy drivers appear most recognized at regional- and national-level organizations. More focus is required to assist smaller, local organizations that constitute the majority of procurers valuing innovation in tender award criteria to better leverage its potential.

1 Introduction

According to Directive 2014/24/EU, public procurement is ‘crucial to driving innovation’ for future growth in Europe that is smart, sustainable, and inclusive (EC, 2014a, p. 83). Policy has opened procurement to innovation by promoting the use of innovative criteria in determining the most economically advantageous tender (MEAT), supporting best price-quality ratios in award criteria. As part of quality-based scoring, the use of innovative criteria is important for innovative procurement (Wegweiser, TU Berlin, & Hölter & Elsing, 2009) as it can improve public services (ICEG, 2012) and stimulate firm innovation (Georghiou, Edler, Uyerra, & Yeow, 2014). Nevertheless, there exists a lack of public demand for innovation (Uyerra, Edler, Garcia-Estevez, Georghiou, & Yeow, 2014) and an emphasis on price (Georghiou et al., 2014) over innovative criteria, where “most public sector organizations still prioritize low-cost over innovation” (ERAC, 2015, p.3). Such a failure to include innovative criteria is a barrier to introducing new innovations through procurement (Dalpé, 1994), and points to a widespread inability of most public organizations to implement innovative procurement and leverage its impacts on growth.

As an exploratory analysis, this paper provides a first attempt to examine the innovation characteristics of public procuring organizations who value innovative criteria in calls for tenders across Europe. We identify taxonomies of innovative procurers to suggest for which type of organizations these policies are being recognized, in terms of innovation profiles, information sourcing, tendering area, and organizational characteristics. The translation of innovative procurement practices into actions, their subsequent effects, and impacts these practices may have on public organizations and on markets are used for validation of the taxonomy.

While the public sector is an important driver for firm innovation, public procurement “has become an important source of innovation in the public sector” (Kattel et al., 2014, p. 23). To help nations stimulate business R&D and innovation, the most recent Innovation Union progress report calls for improvements in innovative procurement and matching with supply side measures (EC, 2014b, p. 13). Government organizations who value innovation in public procurement are important to analyze in understanding how tender inputs and innovative capacities can improve procurement impacts. To the authors’ knowledge, there exist no academic studies that focus on the relationships between innovation in public procurement and institutional characteristics of procurers. While primarily examined on behalf of firms, innovation should also be considered a core activity of public organizations, as it can improve productivity through service efficiency, cost reductions, and stimulating markets (INNO-Grips, 2012). Innovative procurement is a ‘potential conditioning factor’ of public sector innovation, and can also support continued trust from the public and firms (ICEG, 2012, p. 60). Even for innovation in the public sector, few studies exist, consisting overwhelming of case studies and reports that are not generalizable or not grounded in academic theory, respectively (Arundel & Hollanders, 2011; Arundel, 2013; INNO-Grips, 2012).

Existing evidence suggests that while public organizations across Europe may be aware of innovative procurement, it is uncommonly practiced. For example, a German study reported two-thirds of public institutions, at all levels of government, see their organization having high or very high potential in supporting innovative procurement through award criteria (Wegweiser et al., 2009). As well, in a study of the Nordic countries, Bloch (2011) found that organizations expressed interest in public procurement with respect to its relation with public sector innovation. In reality, the additional resources and risks required for engaging in innovative procurement can be cause for its low uptake (INNO-Grips, 2012). For example, a study in the UK found that innovation requirements were only experienced by suppliers in approximately every one in three calls for tender (Georghiou et al., 2014). It is clear that more effort is required across public procurers to promote innovative procurement through the planning and preparatory phases prior to tendering (EC, 2013).

2 Literature Review

The success of innovative procurement depends upon public organizations' capabilities and capacities. Developing a taxonomy, as a classification scheme, based on empirical data can help identify diversity within innovative public procuring organizations by examining characteristics that relate directly and indirectly to innovative procurement. Taxonomies have been used successfully in the past to support studies of "technological regimes" (Nelson, 1977) that reflect technical competency (Pavitt, 1984), and for mapping rates, sources, and types of innovation within organizations (de Jong & Marsili, 2006). For this paper, a preliminary taxonomy will be developed to study innovative procurement by better identifying different types of innovative purchasers.

Developing such a taxonomy presents a significant challenge given lack of literature on which to develop and test classes. In comparison with private sector innovation, public sector innovation has only recently been the subject of academic scrutiny, with much work to be done particularly on methods and indicators development. While similarities with private functions exist, such as cost reduction drivers, differences like profit seeking versus policy or socioeconomic growth (Arundel & Hollanders, 2011) means that innovation taxonomies for public institutions can only draw so much from literature on the private sector. Kattel et al. (2014) see this current recognition of separating the concepts of public and private innovation as marking the "autochthonous theory period", which evolved from the organizational theory period where innovations were often viewed as being similar. However, the European Commission Expert Group on Public Sector Innovation still deems the public sector as a "Schumpeterian Innovator" (EC, 2013, p. 12) with respect to public procurement, with primary impacts in creating new (and temporary) markets for private sector innovation.

Another notable complication is that comparability between public sectors in terms of innovation is often low, since a "unified institutional background with elaborated and widely-used methodology" is largely absent (INNO-Grips, 2012, p. 27), and these commonalities often do not hold when expanded to wider contexts (Peters & Pierre, 2012). This presents particular measurement challenges when using a pan-European sample, underscored by heterogeneity from different levels of governance, intersections with private sectors, and election cycles.

A number of related taxonomies are drawn upon in this paper. In developing a taxonomy of how and strategies for innovation by public organizations, Arundel and Hollanders (2011) identify **policy-driven (top-down) methods, bottom-up methods, and external methods** using an exploratory analysis. They employ variable categories of drivers for innovation, information sourcing for solutions, barriers to overcome, and supporting strategies, validation using innovation method. Similarly, although focusing on firm innovation, de Jong and Marsili (2006) use exploratory analysis to develop four classes of firms: **science-based, specialized suppliers, supplier dominated, and resource-intensive**. Edler (2013) develops a typology of demand-side innovation measures, where with public procurement deemed to be the most direct measure. Aschhoff and Sofka (2009) also examine public procurement amongst other demand side measures, but focus instead on its relative effectiveness in stimulating firm innovation. Taxonomies for innovation procurement presented by Hommen and Rolfstam (2009) expand upon the four-quadrant matrix of Edquist and Hommen (2000) of **developmental and adaptive** procurement (specifying degree of innovation required for the purchase) to include **cooperative and catalytic** procurement according to **learning structures/contexts, demand structure, and needs addressed**. However, this is limited to technological innovation.

A few recent large-scale studies have focused on innovation procurement within contexts of public sector innovation. In the UK, the National Endowment for Science Technology and Arts (NESTA) conducted a pilot survey of UK local government and health care, presenting exploratory studies of public sector innovation and proposing indicators, methodology, and analytical frameworks as recommendations for future analysis (Hughes, Moore, & Kataria, 2011). Similarly, MEPIN (Measuring Public Innovation in the Nordic Countries) examined public innovation in Denmark, Finland, Iceland, Norway, and Sweden, where innovative procurement consisted of the purchase for development or modification of products or processes not yet on the market. Procurements were for acquisition of components or software from ICT-suppliers, acquisition of other machinery and equipment, contracting of consultancy services (ICT, management, user studies, other), outsourcing of service provision, and public-private partnerships (Bloch, 2011). While this does expand from technological focuses of Hommen and Rolfstam (2009), it does not encompass new ways to purchase existing products using innovative criteria, which can also stimulate markets.

Along with their selection and purchase, the use of innovative solutions by government is well integrated into innovation policies (Edler, 2013). To date, a sector-based approach to implementing innovation in public procurement has taken priority over an organizational approach, as exemplified by the EU (EC, 2009), the UK (HM Treasury, 2013), Australia and Finland (ERAC, 2015). A sectoral focus can effectively help innovative procurement to focus on high-potential areas and to be forward-looking for sectors' future needs (ERAC, 2015). The procurement directive has also increased the options by which to accomplish this, promoting the use of pre-procurement consultation, innovation partnerships, and the use of innovative criteria (EC, 2014a). Given this, it is surprising that organizational characteristics have been entirely overlooked when it comes to innovative procurement. In order to adopt these new approaches, purchasers require additional training and effort that entails additional resources and may create process inefficiencies. Different public organizations will have different capacities for introducing innovation in public procurement, dependent upon their characteristics, innovation profiles, and policy drivers. It is the intention of this paper to identify how different they really are.

3 Data and Variables

3.1 Data

Data for public procuring organizations across Europe were obtained from Innobarometer 2010, the largest innovation survey for the public sector (Arundel & Hollanders, 2011). Covering a three-year period, the Innobarometer surveyed 2939 public agencies to measure innovation strategies at the level of their organization from 2008-2010 inclusive, given financial resource constrictions. It was conducted jointly by UNU-MERIT, the European Commission and Gallup Europe. Organizations served geographic areas of local, regional, and national, and ranged from 10 employees to over a thousand. Not-for-profit or a private sector organization were removed from the sample, leaving respondents representing either a government organization, or one owned by the government. For this paper, the criteria for identifying whether an organization conducted innovative procurement was whether they considered *innovation to be at least as important as cost* for an applicant to be successful in winning a tender from their organization. Twenty-one percent (N=604) of the total sample valued cost more than innovation, and 73% (2159) innovation at least as much as cost; 6% (176) did not know or respond. To focus only on innovative procurers, those who valued cost more than innovation were removed from the sample.

Once all the variables were selected and non-responses removed, 920 valid responses remained: 82% (N=755) said cost and innovation have equal importance in public procurement, while the remaining 18% (N=165) said innovation was more important.

It is important to note that, from the phrasing of this question, it is assumed that innovative criteria is included in *award criteria* by organizations. This is supported by three possible answers where innovation and cost are valued in different proportions, relating to price-quality ratios and Most Economically Advantageous Tender (MEAT) calculations supported by the most recent procurement directive. Nissinen, Parikka-Alhola, and Rita (2009) found that a number of requirements set in award criteria, such as specific environmental management measures and policies, are in reality selection (knock-out) criteria that should be presented in the tender body. Therefore, literature and discussion here does not focus only on innovative characteristics in award criteria but rather more broadly on innovative calls for tenders. Also, since no differentiation is made in the question, it is assumed respondents were considering public procurement of innovation (PPI), pre-commercial procurement (PCP), or innovation partnerships (Edquist & Zabala-Iturriagoitia). Examining tendering areas provides further insight into in which of these areas respondents' organizations were more active.

Notably, other surveys have taken a broader approach to measuring innovation in procurement. Possibly due to noted issues with the wording of the questions and respondent confusion, Bloch (2011) found that 17%-50% of respondents indicated they practiced innovative procurement. As well, only half of firms interviewed across Europe in a survey parallel to the Innobarometer (EC, 2012) indicated they had experienced innovation as being at least as important as price in dealing with public tendering. This proportion rises to 74% from Innobarometer respondents. Further examining innovative practices within the Innobarometer sample of these innovative procurers may help uncover more realistic practices of innovative procurement.

3.2 Clustering Variables

Building upon the literature on taxonomies of innovative procurers, seventeen variables were selected to test for clusters within the data. The following explains these variables and contextualizes them in relevant literature.

Table 1 – Variables used to develop the taxonomy of innovative public procurers

Variable	Description	Interpretation
<i>Innovativeness and Effects of Innovation</i>		
q6_b	Introduced delivery/logistic systems innovations	Yes=1; No=0
q4dm	New service innovations , as a percentage of total services - <i>Dummy variable created by combining categories of 25-49%, 50-74%, and 75-100%.</i>	>25% = 1 =< 25% = 0
q12_3	Process/organizational innovation led to faster service delivery	Yes=1; No=0
<i>Consulting and Information Sourcing – innovation input</i>		
q7_d	Process/organization innovations developed independently	Yes=1; No=0
q7_b	Process/organization innovations developed in collaboration with private business	Yes=1; No=0
q14_fdm	Importance of information from enterprises (as suppliers) in developing innovations - <i>Dummy variable created by combining categories of “somewhat important” with “very important”</i>	Somewhat /Very important=1 Not important=0
q20_1	Consult potential suppliers /contractors before tendering	Yes=1; No=0
q20_2	Consult service users of before tendering	Yes=1; No=0
q20_4	Consult organizations with special advice before tendering	Yes=1; No=0
<i>Put out tenders to private businesses (goods or services) in the following areas</i>		
q19_a	ICT equipment/ systems	Yes=1; No=0
q19_b	Technologies/services to improve environmental/energy performance	Yes=1; No=0
q19_c	Other types of technology	Yes=1; No=0
q19_f	Provide one or more user services	Yes=1; No=0
q19_d	Consulting to recommend/design/pilot test service innovations	Yes=1; No=0
q19_e	R&D for new technologies and services	Yes=1; No=0
<i>Organizational information</i>		
d1dm	Employee number - <i>Dummy variable created by combining categories of 10-49, 50-99, 100-249, 250-400 to make one category, and 500-999 with 1000 or more to make the other category</i>	>=500=1 10-499=0
d4dm	Geographic area served by organization - <i>Dummy variable created by combining regional and national</i>	Regional/National=1 Local=0

3.2.1 Innovativeness and Effects of Innovations

Compared with the private sector, which is driven by revenue generation, the public sector has a wider range of objectives for its innovations. In the effects of innovations, we examine only outcome measurements innovation, as *introduction of innovations in delivery or logistic systems* (as a subset of process or organizational innovations), *new service innovations as a percentage of total services*, and *introduction of process or organizational innovations that significantly increased service delivery*.

Bloch (2011) found the majority of innovations introduced in a survey of public sectors in the Nordic countries to be ICT innovations, spanning product, process, organizational, and communication classifications of innovation. In the same study, almost half of respondents noted that an important objective for administration innovation was improvement of online services (Bloch, 2011). Service innovations can create cost reductions by streamlining procedures, with private sector parallels (INNO-Grips, 2012). Improvement in public services is a driving factor in firm success due to its influence over business environments through public procurement competitions (Hollanders et al., 2013). This effect is two-directional: private sector innovation also raises public standards for performance of public institutions (INNO-Grips, 2012).

Innovative procurement is a itself measure of service innovation, which can influence business environments and drive firm success (Hollanders et al., 2013). However, as innovations in the public sector do not face same market forces as private innovations, the best innovations are not always those chosen (INNO-Grips, 2012). Instead, pressures facing public institutions to select better innovations come from a desire to mitigate financial risks associated with the failures from suboptimal solutions (INNO-Grips, 2012); facing this risk can create aversion to innovation.

3.2.2 Consultation and Information Sourcing

Innovative procurement entails an interface between public organizations and external actors that “shape the innovation process” (Bloch, 2011, p. 18). Since the tendering areas included as variables in this paper are intrinsically innovative, they will be shaped by the degree of independence or collaboration in approaches to innovation development (process/organization innovations developed *independently*, or *in collaboration with private business*). The *importance of supplier information in developing innovations*, and the *consulting of potential suppliers before tendering* are also used to capture the relationships between innovative procurers and their suppliers. *Consultation of service users* and *consultation of organizations with special advice* in the pre-procurement period are also included. *Consultation of other innovative procurers* is used as a validation variable, as discussed in Section 3.3.2. The question in the survey was phrased as “usually consulted” each particular party prior to tendering, which is interpreted here as meaning that, in most instances and as a common practice, procuring organizations sought information from the specified source.

Collaboration is a public sector strategy to “support or encourage” innovation (Arundel & Hollanders, 2011, p. 5). It “implies greater scope for experimentation” INNO-Grips (2012, p. 57) through risk sharing that can increase the openness of calls for tenders and thus improve their innovation outcome. In comparison with information sourcing for private sector innovations, public sector consultation requires greater specificity in its sources than provided by the general categories in the Oslo Manual (by the firm alone, together with others, or primarily by others) (Bloch, 2011). This variety is reflected in questions from the Innobarometer used in this paper.

The degree of internal and external connectedness was found by Hughes et al. (2011) to be a critical factor in enabling public sector innovation, in which competitive tendering and establishing collaborations through partnerships introduces competition to the public sector (INNO-Grips, 2012). Additional information gathering required for introducing the right innovative criteria places higher demands on resources required to develop tender. Greater “institutional closeness” (INNO-Grips, 2012, p. 36) between public organizations and others helps “maximise learning and often minimise risks” (Bason, 2010, p. 240). However, capacities for collaboration are influenced by institutional setting (Huxham & Vangen, 2005), and a lack of dialogue between purchasers and potential suppliers can hinder innovation (Uyarra et al., 2014). Even though Hughes et al. (2011) found “the majority” of ideas from the public sector to be externally sourced, underscoring the importance of external connectedness, the majority of ideas generated in this manner were not often turned into innovations (Hughes et al., 2011).

Sharing information with potential suppliers, particularly at early stages of procuring a radical innovation (including pre-commercial procurement stages), enables planning of capacity and

“innovation investment to react to public sector needs” (Tsipouri, Edler, Rolfstam, & Uyerra, 2010, p. 41). Suppliers identify a lack of opportunity to present unsolicited ideas as an area for concern (Uyerra et al., 2014). Improving the efficiency and use of pre-procurement consultation through dialogue with potential suppliers is a focus of the UK in improving the design and delivery of procurement processes (HM Treasury, 2013). Pre-procurement market consultation is increasingly preferred to competitive dialogues once tenders are open, with a small minority of governments in the UK practicing this (Uyerra et al., 2014) while its use is becoming more efficient (HM Treasury, 2013). In France, procurers began networking with potential suppliers at events since 2014 to connect with high-potential industry partners and to better find SMEs (ERAC, 2015). As well, the type of innovation procurement in general should influence the sourcing of information. For new technologies, for example, intensified dialogue between the public sector and firms active in R&D is widely perceived to influence public sector innovation (Wegweiser et al., 2009).

Consultation and collaboration are a prerequisite for public-private innovation partnerships. Public-private partnerships in procurement are a form of cooperation under the New Public Management paradigm (Essig, 2005), where government works more closely with businesses, social enterprises and NGOs (Walker, 2008). In an innovation partnership, which specifically refers to partnership with a private firm, a buyer works together with a single supplier over a multi-year period to purchase the product or service at the point of commercialization (Georghiou et al., 2014). In the new procurement directive, procurers are advised to establish innovation partnerships with companies through procurement mechanisms, particularly for long-term activities in developing new products (EC, 2014a). Such public-private innovation partnerships are “extremely important” for identifying innovations for significant cost-savings and “improved service quality and accessibility” (INNO-Grips, 2012, p. 59). Examining these partnerships in smart city initiatives, INNO-Grips (2012) found them to be more common in “either federal or highly decentralized institutional settings” (p. 44) of the UK, Germany, Netherlands, Italy, and Spain. Such partnerships can be used instead of multi-stage tendering with multiple companies in pre-commercial procurement (PCP).

Interactions between producers and users further innovation through learning (Von Hippel, 1988). Public purchasers consulting with service users in pre-procurement discussions act as a liaison between users and producers, as in “catalytic” procurement when the end-user is a third-party and the government buys a product or service to stimulate a (new) market in a desired way (Edler, 2013; Hommen & Rolfstam, 2009). Through user-supplier interaction and co-production, procurement helps to induce or diffuse innovations (Edler, 2013). In catalytic procurement especially, user consultation “helps improve the acceptability of the marketplace and thus reduce market risks” (Tsipouri et al., 2010, pp. 40-41). User satisfaction is a common objective in Nordic procuring institutions (Bloch, 2011), such as Denmark, which promotes market dialogue and identification of user needs in innovation procurement (ERAC, 2015). Additionally, as access to skills is a critical enabling factor of public sector innovation (Hughes et al., 2011), consulting external organizations for special advice may be more highly associated with innovative procurement. Special skills can help risk adverse organizations begin innovation procurement in the face of complex criteria decisions. (EC, 2013).

Regarding development through internal consultation, the success of innovations developed by organizations independently is influenced by internal diffusion methods (Hughes et al., 2011). For organizational innovation, extensive internal collaboration can help to identify solutions, as seen in the example of internal nutritional system improvement in Norwegian hospitals (Corbin, Corwin, &

Mittelmark, 2012). Within organizations, stimulating an “innovation culture” at procuring institutions is required to give public purchases the tools and expertise to conduct innovative procurements and mitigate their associated risks.

3.2.3 Tendering Area to Private Suppliers (goods or services)

To examine organizations with respect to tendering areas, variables were included for which goods or services were procured. These are *ICT equipment/ systems; Technologies/services to improve environmental/energy performance; Other types of technology; Provide one or more user services; and Consulting to recommend/design/pilot test service innovations*. Many of these variables are analogous to those used by Bloch (2011), while *energy/environmental technologies* and *user services* are distinct.

As the sample is for public organizations who value innovation in calls for tenders, and the listed tendering areas are all innovative, it is assumed that if an organization tendered in the area then it included innovative criteria and that the purchase was for (or an example of an) innovation. An exception is for *R&D for new technologies and services*, which is not necessarily tendering for an innovation, as distinguished from PCP, unless it falls under an innovation partnership arrangement where the procurement contract with a single supplier says the public sector will purchase the innovation at the point of commercialization. This variable is akin to MEPIN’s “public private partnerships” question to test for innovative procurement (Bloch, 2011).

ICT innovations are the most often cited as relevant to both public sector innovation and innovative procurement. They can have similar benefits for the public sector as in the private sector, and support knowledge management and non-technological innovation by enabling stakeholder dialogue, enabling organizational and systems innovation (INNO-Grips, 2012). As such, the quality of ICT infrastructure can be a critical organizational enabler of innovation (Hughes et al., 2011). Also associated with increasing service quality and cost-effectiveness, tendering for one or more user services indicates outsourcing (INNO-Grips, 2012) and a better focus on core government mandates. In comparison with helping meet primary policy goals through procurement, improving environmental/energy performance is often a secondary policy measure, driven by policies as a top-down innovation.

In a review of PCP, Bedin, Decarolis, and Iossa (2014) found that many initiatives did not require a significant R&D effort, with many relying on a single supplier rather than transitioning through multiple stages with multiple companies, and also many resulting in organizational innovations and “incremental applied research” (p.12).

3.2.4 Organizational information

To examine organizational information, variables for organization size (*number of employees* and *geographic area served*) were introduced to the model. A number of findings have supported relationships between these factors and the degree of innovation in public sectors, although not with respect to innovation procurement. Institutional structure influences the actions of public sector innovators (INNO-Grips, 2012). According to Arundel and Hollanders (2011), the likelihood of service innovation increases with the size of the public institution, where smaller organizations have less external information sourcing compared with larger organizations. Earlier findings corroborate this, such

as Gow (2014), who found larger Canadian institutions were more innovative in terms of adopting new administrative processes or organizations from 1960-90. With respect to applying the results of procurements, Bloch (2011) found central (i.e., national) government to use their ICT procurements more often to promote innovation in suppliers.

3.3 Variables used for Validation

A number of additional variables were used to validate the cluster analysis. These are displayed in Table 2 and described in greater detail in the following sections.

Table 2 – Variables used to test the taxonomy of innovative public procurers

Variable	Description	Interpretation
<i>Innovative results of tenders</i>		
q11_2	Service innovation improved targeting of services	Yes=1; No=0
q11_3	Service innovation improved user satisfaction	Yes=1; No=0
q20_3	Consult other organizations conducting similar procurement before tendering	Yes=1; No=0
q22_1	Tender resulted in service innovation	Yes=1; No=0
q22_2	Tender resulted in reduced service provision costs	Yes=1; No=0
q22_3	Tender resulted in significantly reduced environmental impact of services	Yes=1; No=0
countinno	Whether country is has developed frameworks for innovative public procurement	Yes=1; No=0

3.3.1 Service Innovation Outcomes

Metrics for validating cluster variables were outcomes of service innovation, as new or significantly improved services, in terms of *improved targeting of services* and *improved user satisfaction*. Market metrics on innovation outcomes such as increased turnover or market share do not have direct parallels for public institutions. With goals based more on societal assistance, “improved responsiveness” to clients or citizens of public institutions is a critical metric for measuring public sector innovation outcomes, underpinned by policy objectives for socioeconomic growth (INNO-Grips, 2012). Whether public purchasers offer entrance to lead markets, or act as experimental or lead users, the use of innovations is necessary for their diffusion (Edler, 2013). With public purchasing in 2009 across Europe amounting to 19.4% of GDP, procurers have a lot of leverage they can exert by acting as ‘launch customers’ (ERAC, 2015, p. 4).

3.3.2 Consultation of Other Innovative Procurers

The validation variable *consultation of other organizations conducting similar procurement before tendering* complemented other consultation mechanisms as clustering variables. In certain types of procurement, such as “co-operative” (or “joint” (ERAC, 2015)) procurement, collaboration is mandatory as procurers work with other public entities to organize the purchase and specify needs together (Hommen & Rolfstam, 2009). Governments across Europe are beginning to establish collaborations between procurers. There are a growing number of examples of joint procurements and those involving networks for consultation, with European backing like by eafip (European Assistance for Innovative Procurement) toward fostering networks for innovative procurement. It is expected that consultation with other governments is often associated with consultation of other parties (suppliers, users, special advisors), and that may be a prerequisite for it. One example is collaborations in the Netherlands between municipalities of four regions (Metze & Levelt, 2012), who found that best interests or

innovation expectations are not always met with all parties. Collaborations are a prerequisite for innovative public finance such as networking grants (Baliey, Valkama, & Anttirokio, 2010) that can help remove financial barriers to innovative procurement.

Although a prerequisite for innovation procurement policy, many member states lack coordination and cooperation across Europe (ERAC, 2015). Institutionalization of driving principles by certain public organizations has helped to overcome this. Austria, for example, has developed a clear governance structure across its three ministries cooperating in PCP and PPI without building a new entity, combining knowledge, knowhow, and experience to be shared between purchasers (EC, 2015). Holland has also introduced an innovation strategy for procurement on the organizational level. At the sectoral level, implementation of innovative procurement through a sector-by-sector approach, such as led by Category Managers in federal procurement in the Netherlands, and supported by sectoral strategies can ease implementation of innovative procurement. Bloch (2011) found organizational innovation practices in Nordic countries through external cooperation of public administration institutes.

3.3.3 Tender Innovation Outcomes

Innovation outcomes from tenders measured whether at least one tender during the 3-year timeframe of the study resulted in *service innovation (new or significantly improved service provided by or for your organization)*, *reduced costs of service provision*, or *reduced environmental impact of services*. If public bodies adopt procured innovations themselves, they act as a first user and help establish demand in new markets, while benefiting in their own cost reductions or improved services. Acting as an early user of procured innovations can support the diffusion of cost-effective technology and services, supporting product improvement and speeding up cost reductions (Aschhoff & Sofka, 2009).

Not all tenders from an innovative procurement must result in an innovation, which is complicated by frequent confusion of pre-commercial procurement, public procurement of innovation, and innovation partnerships (Edquist & Zabala-Iturriagagoitia, 2015). Innovative procurements are more likely to be based on longer-term and explorative contracts (INNO-Grips, 2012), such that it is not inevitable that these contracts result in innovations. EC (2012) found approximately a quarter of firms who were awarded tenders from public procurement had the possibility of selling an innovation to the government. The European Commission stresses that PCP activities are necessarily for R&D services and must terminate prior to uptake or commercialization, and therefore exclude activities such as 'integration, customization, incremental adaptation and improvements to existing products or processes' (EC, 2007, pp. 2-3). As such, public organizations are not allowed to purchase innovative solutions that have been developed through PCP mechanisms, as this would be covering the costs of commercialization. As well, if the purchase is "catalytic", as described in Section 3.3.2, the government is not the end user and thus would not implement any innovations that were purchased.

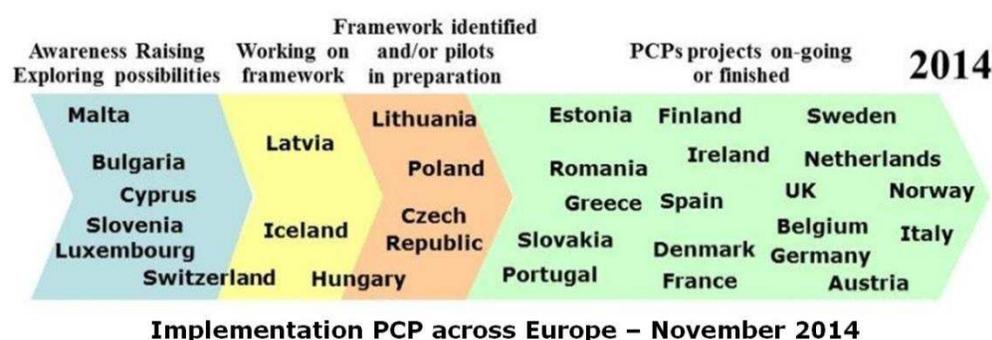
3.3.4 Policy Drivers

Finally, the policy environment of the organization was measured by testing whether organizations belonged to a country which had developed frameworks for innovative procurement or not. Innovation at the organizational level is often driven by policy (Petkovšek & Cankar, 2013, p. 1331). Arundel and Hollanders (2011) found new laws and regulations to be the most important driver of innovation in the public sector, while Hughes et al. (2011) found organizations with innovation strategies to have better innovation measures over the whole sample. However, only recently have “dedicated innovation policy approaches” been targeting demand-side measures (Edler, 2013, p. 5). For government organizations, primary policy objectives of public procurement are efficiency and cost effectiveness. Secondary could include “sustainable green growth, the development of small and medium-sized enterprises, innovation, standards for responsible business conduct or broader industrial policy objectives” (OECD, 2015, p. 138). Policies prompting innovation in public procurement are an “example of public sector innovation that combines institutional and administrative aspects (e.g. how bids are evaluated) and technological skills and innovations in the private sector” (EC, 2013, p. 15).

The vast majority (94%) of OECD countries policies or strategies to support green public procurement, small and medium-sized enterprises, and/or innovative goods and services, while a much smaller proportion measure their results (OECD, 2015). For innovative public procurement, policy motivation is a top-down innovation method (INNO-Grips, 2012), and achieving secondary objectives requires the inclusion of innovative criteria, which can be placed either in calls for tenders (as technical specifications/requirements, also referred to as selection criteria) or award criteria (Nissinen et al., 2009). Recently, the European Research Area and Innovation Committee (ERAC) has called for countries across Europe to “create a strategic framework for innovation procurement” and an action plan, along with establishing a centralized national coordinating service to support procurers and promote innovation in purchasing (ERAC, 2015).

In developing this variable, countries who have ongoing or completed PCP projects were said to be “innovative”, as they have moved through the stages from exploration, to framework development, to identification and pilot preparation (EC, 2015). This was used as an indicator of whether the countries conducted PPI as well – i.e., not procuring R&D services but purchasing a new innovative product or service. As the dataset surveys organizations from 2008-2010, those who are innovative in 2014 would have been in earlier stages of developing policies for this in prior years, and those who in 2014 had not yet begun projects would have been farther behind 4-6 years earlier. While remembering that PCP is not the same as the public procurement of innovation, this was the best approximator for a policy environment conducive to innovative procurement given the lack of comprehensive study in this area.

Figure 1 – Implementation of pre-commercial procurement projects across Europe (EC, 2015)



4 Method

Focusing on the 920 government organizations who valued innovation as least as much as cost in their public procurements, a three-stage exploratory analysis was undertaken to examine differences and similarities within subgroups, following the approach of de Jong and Marsili (2006) and Leiponen (2008). While one drawback of cluster analysis is its subjectivity across different data sets and theoretical lenses, its rigour can be enhanced by identifying commonalities between broad categories and clusters in prior analyses (Arundel & Hollanders, 2011).

4.1 Principal Component Analysis

First, a principal component analysis (PCA) was performed to reduce the number of variables to be used in the cluster analysis. Seven variables were removed due to a low individual Kaiser-Meyer-Olkin measure of sampling adequacy score, and later used for validation. With the remaining variables combined, the KMO score was 0.75, and for each individual variable was above the minimum required of 0.60 (Table 5, Appendix). An extraction technique with varimax rotation was used, and the latent root criterion required that eigenvalues be greater than one. This gave six components with an eigenvalue greater than one, explaining a cumulative 50.1% of the variance in the dataset. A three-dimensional solution explained 31.3% of variance. There was no indication of issues from high multicollinearity, with all values below 0.3374 (Figure 2, Appendix). The determinant for the correlations was 0.08556, which was greater than the necessary 0.00001 (Arundel & Hollanders). The highest correlation value was 34.5% (Figure 2, Appendix).

4.2 Cluster Analysis

Using the variables presented in Section 3, the cluster analysis was performed. While cluster analysis is sensitive to outliers, all had standard deviations much lower than the acceptable limit of between 2 and 3, according to Hair et al. (1998). When considering the number of potential clusters, between three and six were considered to be desirable a priori, with fewer than three offering little explanatory power and more than six requiring greater literary basis than what is available for explanation. Hierarchical and

non-hierarchical techniques were combined to define centroids for a k-means cluster analysis based on Ward's Euclidian distances (de Jong & Marsili, 2006; Punj & Stewart, 1983; Singh, 1990).

For the *hierarchical component*, and following (Singh, 1990) until kappa validation stage, a Ward's linkage with Euclidian distances – as a continuous dissimilarity measure - was generated. Using this, a dendrogram was developed for visual inspection of an appropriate number of clusters to test. Due to the high number of observations, the dendrogram was limited to the top 15 branches (Figure 3, Appendix). From here, 2-5 clusters were seen to be feasible, with a three-cluster solution having a more unequal number of observations. A three-cluster centroid was developed using the Ward's linkage.

For the *partitional component*, this three-cluster centroid was used as a starting point in performing a k-means cluster analysis with three clusters. Focus variables were then displayed according to this new k-means cluster solution, then kappa was calculated between the cluster analysis solution and the initial hierarchical solution. Kappa tests for randomness in agreement, and calculates the chance correlated coefficient of agreement. This process was repeated for solutions of 4 and 5 clusters, and the percent agreement compared between the three solutions. The three-cluster solution had the highest agreement at 76.41% and a kappa of 0.6345 (Table 3), greater than those for either the 4 or 5 cluster solution (both with 65%).

Table 3 – Kappa for 3-cluster solution

Agreement	Expected Agreement	Kappa	Std. Err.	Z	Prob>Z
76.41%	35.46%	0.6345	0.0235	27.03	0.0000

5 Results

5.1 Descriptive Statistics

Column 6 in Table 6, below, presents the means for each variable used in the cluster analysis and validation. For innovativeness and effects of innovation, more organizations provided faster services as an outcome of process or organizational innovations. In contrast, almost half of organizations introduced delivery or logistic systems innovations, on average. Similarly, almost half improved less than 25% of their services offered, whereas the other half improved greater than 25%.

The highest average for institutions on consulting and information sourcing, as innovation input, was in development of process or organizational method innovations by the organization alone (i.e., without external consultation). Approximately 67% of respondents saw enterprises, as suppliers, as important information sources for development of innovations. In consulting parties for information to be used in tender development, discussions with other organizations conducting similar procurements was most common (69%), followed by potential suppliers/contractors (62%), other organizations with special advice (59%) and service users (56%). The first of these was measures used for validation purposes due to a relatively low KMO score. For processes or organization innovation, organizations more commonly developed these by themselves, while only half of organizations collaborated with private businesses in this regard.

In tendering areas, 80% of all organizations had put out tenders to private businesses for goods or services in the area of ICT equipment or systems. Tenders to provide service(s) to their users was the second most common, at 72%. Next was procurement of technologies or services to improve environmental or energy performance (65%), followed by other types of technology (60%) and consulting to recommend, design or pilot test new or improved services (56%). Finally, only 39% of organizations procured R&D for new technologies and services.

Regarding organizational characteristics, the majority (685, almost 75%) of organizations were at the local level, with fewer at the regional (18%) and national (7%). The latter two categories were combined such that a total of 235 organizations served regional or national geographic areas. Employee numbers are also quite low, with 93% (723) having less than 500 employees. It is notable that, before a dummy variable for employee number was created, the most common size category was 1-49 employees, supporting the small geographic area served by the many local organizations.

Between the validation variables, means did not vary as greatly. Almost three-quarters of organizations had a tender result in a new service innovation, whereas 58% had at least one resulting in significantly reduced costs of providing existing services and only half had one or more result in reduced environmental impact of their services. Effects of service innovations were more common in comparison, with again almost three-quarters of organizations reporting service innovations enabled better targeting of services, and 84% reporting improved user satisfaction. For whether the organization belonged to a country deemed to be innovative in public procurement, on average 77% were from such countries.

5.2 Empirical Taxonomy

The results of the cluster analysis are presented below, in Table 4.

Table 4 – Cluster analysis and validation for a three-cluster solution, using k-means cluster analysis with centers based on ward's linkage and Euclidian distances

Variable		Cluster			Mean	F-Value
		1	2	3		
<i>Innovativeness and Effects of Innovation (not tender-specific)</i>						
q6_b	Introduced delivery/logistic systems innovations	0.60	0.52	0.33	0.46	27.4***
q4dm	New service innovations , as a percentage of total services	0.41	0.76	0.29	0.45	77.1***
q12_3	Process/organizational innovation led to faster service delivery	0.90	0.79	0.65	0.76	30.9***
<i>Consulting and Information Sourcing – innovation input (organization and tender level)</i>						
q7_d	Process/organization innovations developed independently	0.88	0.72	0.63	0.73	28.6***
q7_b	Process/organization innovations developed in collaboration with private business	0.84	0.49	0.30	0.51	124.9***
q14_fdm	Importance of information from enterprises (as suppliers) in developing innovations	0.79	0.82	0.49	0.67	54.3***
q20_1	Consult potential suppliers /contractors before tendering	0.82	0.65	0.47	0.62	49.2***
q20_2	Consult service users of before tendering	0.87	0.35	0.48	0.56	100.7***
q20_4	Consult organizations with special advice before tendering	0.86	0.35	0.55	0.59	84.0***
<i>Put out tenders to private businesses (goods or services) in the following areas</i>						
q19_a	ICT equipment/ systems	0.92	0.92	0.66	0.80	54.2***
q19_b	Technologies/services to improve environmental/energy performance	0.78	0.76	0.50	0.65	41.6***
q19_c	Other types of technology	0.86	0.67	0.38	0.60	98.0***
q19_f	Provide one or more user services	0.87	0.88	0.53	0.72	80.4***
q19_d	Consulting to recommend/design/pilot test service innovations	0.84	0.74	0.26	0.56	188.9***
q19_e	R&D for new technologies and services	0.57	0.72	0.07	0.39	250.9***
<i>Organizational information</i>						
d1dm	Employee number	0.55	0.06	0.07	0.21	189.9***
d4dm	Geographic area served by organization	0.42	0.22	0.17	0.26	29.2***
<i>Validation variables</i>						
q11_2	Service innovation improved targeting of services	0.87	0.73	0.66	0.74	19.0***
q11_3	Service innovation improved user satisfaction	0.91	0.83	0.79	0.84	9.5***
q20_3	Consult other organizations conducting similar procurement before tendering	0.85	0.53	0.68	0.69	34.3***
q22_1	Tender resulted in service innovation	0.88	0.76	0.70	0.77	14.5***
q22_2	Tender resulted in reduced service provision costs	0.74	0.54	0.49	0.58	22.5***
q22_3	Tender resulted in significantly reduced environmental impact of services	0.61	0.43	0.45	0.49	10.9***
countinno	Whether country is "innovative" or not in PP	0.92	0.83	0.74	0.82	17.6***
N		277 (30.1%)	234 (25.4%)	409 (44.5%)	920	

* A significance level of 10%. (<.1)

** A significance level of 5%. (<.05)

*** A significance level of 1%. (<.01)

5.2.1 Cluster 1 – Collaborative innovative procurers, organizational innovators

Organizations in this cluster have the highest score on almost all variables compared with the other two clusters. They comprise 30.1% of the sample. More than half of these organizations have 500 or more employees, making them much larger than the other two clusters. Their geographic area served also reflects this, as they are more regional and national than the others. The majority (90%) have introduced process or organizational innovations that reduced service delivery times, while 60% introduced delivery or logistic systems innovations.

Their knowledge sourcing is a common practice and sources are varied. They usually consult an equal proportion of potential suppliers, service users, and specialists (86-88% of organizations) when developing calls for tenders. Similarly, they consult private businesses when developing processes or organizational method innovations (84%), while at other times relying solely on internal knowledge. Overall, for information sourcing for both public procurement and innovation, they rank highest, with the exception of slightly fewer, on average, consulting enterprises (as suppliers) in developing innovations when compared with Cluster 2.

Most organizations in this cluster procure ICT equipment or systems (92%), supported by tenders for the provision of user service (87%). In this profile, they are nearly identical to Cluster 2, as well as in tendering for improvement in environmental or energy performance where both had over 75% of organizations active. However, those in Cluster 1 rank much higher in procuring other types of technology. Notably, across all clusters there are more organizations in Cluster 1 who are active in consulting to recommend, design, or pilot test service innovations.

5.2.2 Cluster 2 – Pre-Commercial Procurers, outsourcers, service innovators

In developing innovations, the 25.4% of organizations in Cluster 2 see enterprises (suppliers) as more important than Cluster 1, but relatively fewer contact them in comparison when developing tenders. They have the highest proportion of new service innovations; this is not reflected in consulting potential suppliers prior to tendering, where they remain second in rank to Cluster 1. They are particularly different from organizations in Cluster 1 in not consulting service users or others with special advice to gather knowledge for developing calls for tenders. In this, they rank lowest across the three clusters, with only 35% of organizations consulting in this way. In contrast, tendering for service provision to users was the most common across all clusters, at 88% of organizations.

Most organizations procured R&D services for new technologies or services, as pre-commercial procurement, ranking them first among the clusters. The same proportion as in Cluster 1 tenders in the area of ICT and for improvements in environmental or energy performance. Almost three-quarters of these organizations develop process or organization innovations alone. These organizations have small employee numbers (almost identical to Cluster 3), but a higher proportion serve larger geographic areas than do those in Cluster 3.

5.2.3 Cluster 3 – Independent, infrequent direct procurers

Organizations in Cluster 3, comprising 44.5% of the total sample, rank below those in Clusters 1 and 2, on average, in all variables except consulting service users or others with special advice prior to

tendering. Even though fewer publish tenders across all tendering areas, a higher proportion consulted with service users (48%) and others with special advice (55%) prior to tendering. Only a small proportion consults to recommend, design, or pilot test new or improved services, and almost none (only 7%) conduct PCPs, by tendering R&D services. This is likely due to their small size and lower employee numbers, indicating they are mostly local government organizations that source some external knowledge when required.

5.3 Validation

A validation analysis was done to test for significant differences between the identified clusters, following the method of de Jong and Marsili (2006) by performing a MANOVA test and then applying to additional variables not included in the PCA to the clusters. Validation variables were those excluded due to lower KMO scores, but were also predicted to vary across clusters. Identifying for significance between variables used, a MANOVA test for all variables (Pillai's Trace is 1.2113, F-value = 57.28 (approximately distributed) and $p < 0.001$ [Table 4]) indicated a differences between the 24-dimension mean vectors (24 dependent variables) of the three clusters, allowing for the null hypothesis that the mean vectors are the same for the three clusters to be rejected. Findings were confirmed by multivariate regressions for one-way analyses for each variable (Table 4).

The validation variables mapped across clusters as expected according to their interpretation. With more tendering and pre-tender consultation, Cluster 1 also had more innovation resulting from its tenders, and many more (85%) consult other procurers prior to tendering than do other clusters. Overall, their tenders have more innovative outcomes than the other clusters, and a higher percentage (92%) of their countries have innovative procurement policies in place. Coinciding with its focus on supplier consultation, Cluster 2 was least likely to consult other government organizations with similar procurements, at only 53%. A PCP and outsourcing approach is supported in this cluster given fewer innovative outcomes for the organization from tendering, as well as less common user consultation (35%) in combination with commonality of user service provision (88%) and improved user satisfaction (83%). The exploratory nature of their contracts (or perhaps the practice of catalytic procurement) is supported by lower environmental/energy impacts of their tenders in comparison with their frequency.

For Cluster 3, almost all validation variables were consistent in ranking third across the clusters. Exceptions are that, compared to Cluster 2, a higher percentage consulted other procuring organizations prior to tendering, and only slightly (2%) more had a tender result in reduced energy/environmental impact. This may indicate that the tenders they produce in this area are more effective than either those in cluster 1 or 2, or at least targeted more toward improvement attributed to their own institution (direct procurement).

6 Conclusions

From the exploratory taxonomy of innovative public procurers developed in this paper, three different types of organization were suggested based on concepts from related taxonomies in literature. Cluster 1 reflects characteristics of national organizations conducting PPI through co-operative procurement, purchasing (and often implementing) innovative solutions and driven by innovative procurement policies. They have high levels of collaboration from multiple sources for tendering and in general, and introduce organizational innovations. Cluster 2 encompasses more regional organizations who are active in innovation partnerships, PCPs, and outsourcing of service provision, with low innovation benefits from what innovative tendering does take place. These organizations may be acting as catalytic procurers instead of end-users, and outsource service provision to users by procuring it such that they have less motivation to consult service users themselves. While a high percentage of service innovations introduced may indicate that these were relatively minor (Arundel, 2013), introduced innovations may be *more* significant than for other clusters, since while a lower proportion was new, almost all resulted in significant improvements in the speed.

Cluster 3 reflects small municipal-level organizations who tender infrequently and rely on specialist advice prior to tendering, but also are better connected to service users. These findings support the closer connection of more local institutions to the needs of users. Their tender outcomes are not as effective for innovation impacts at the organizational level, although overall they rank lowest for innovativeness in general. They have not internalized many of the capacities associated with innovative procurement, and hence require specialist advice.

Based on the results, there appears to be a divide between those practicing PPI and PCP in terms of information sourcing and organizational characteristics. Innovative procurement may be at odds with New Public Management approaches to public services, and resource availability (for improvement of innovative tenders) and policy pressure (as drivers) appear most significant for large organizations serving regional and national geographies. Findings corroborate ERAC recommendations to establish a “European Union knowledge service on innovation procurement” that provides direct and targeted support for public procurers and policy makers (ERAC, 2015). While this initiative would be targeted to those doing cross-national procurements and national service centers, perhaps more focus is required to assist smaller, local organizations that constitute the majority of procurers valuing innovation in tender award criteria. Otherwise, a mechanism to promote consultation of procurers conducting similar procurements may be similarly effective. The provision of dedicated funds provided by national and regional procurers to establish such a knowledge service initiative might indeed help finance the improved penetration of innovative procurement policies to action, “improve the efficiency and quality of public services”(ERAC, 2015, p.15). In conclusion, our research supports that the use of public procurement in driving public services innovation has “not yet been sufficiently realized” (EC, 2014, p.17). However, we underscore that measuring the effects of innovation procurement requires an improved taxonomy for better delineating various mechanisms of innovative procurement with respect to heterogeneous public organizations.

7 Limitations

This research addressed impact and innovation activity measures for public institutions by focusing on more conventional innovation measures associated with public procurement activities, such as consultation practices and service impacts. Due to the nascency of this research area and the explorative approach, we did not focus internal dynamics like top-down or bottom-up innovations, although these are it is widely cited that many barriers to innovation come from within public organizations (Gow, 2014). This would entail a more detailed level the motivations for employees to innovate, a distinct field for the public sector given unique deterrents such as no financial rewards for innovation, a risk adverse attitude, and an inability to learn from failure (INNO-Grips, 2012). A more developed taxonomy should account for innovation capability (including leadership and culture, management of innovation) and wider sector conditions for innovation (incentives, autonomy, leadership and culture) (Hughes et al., 2011). Degree of institutional autonomy, while often associated with size/geographic area served (Arundel & Hollanders), was also not included. A dataset to capture this more indepth information on how public organizations innovate requires careful development, since there is greater heterogeneity in this area than across the innovations they produce (Bloch, 2011). As per suggestion of Bloch (2011), targeting specific groups of institutions with more specific questions tailored to their particular innovation methods and processes, such as for public health care or education facilities, might be an effective way to do this within broader surveys.

8 References

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9 Appendix

Table 5 - Kaiser-Meyer-Olkin measure of sampling adequacy

Variable	kmo
q12_3	0.7405
q6_b	0.7414
q4dm	0.6692
q20_1	0.684
q20_2	0.7189
q20_4	0.6776
q7_b	0.8232
q7_d	0.7995
q14_fdm	0.7515
q19_a	0.7662
q19_b	0.7019
q19_c	0.805
q19_d	0.7888
q19_e	0.7598
q19_f	0.8031
d1dm	0.7677
d4dm	0.6494
Overall	0.7545

Figure 2 – correlation matrix, PCA variables (all)

	q12_3	q6_b	q4dm	q20_1	q20_2	q20_4	q7_b	q7_d	q14_fdm	q19_a	q19_b	q19_c	q19_d	q19_e	q19_f	d1dm	d4dm	q22_1	q22_2	q22_3	q11_2	q11_3	q20_3	
q12_3	1																							
q6_b	0.1379	1																						
q4dm	0.116	0.1274	1																					
q20_1	0.1127	-0.0049	0.0029	1																				
q20_2	0.0736	0.0715	-0.0214	0.1509	1																			
q20_4	0.1025	0.017	-0.0573	-0.0203	0.1523	1																		
q7_b	0.1156	0.0997	0.0481	0.1117	0.1181	0.1069	1																	
q7_d	0.1145	0.1229	0.0898	0.0601	0.0682	0.1056	0.0461	1																
q14_fdm	0.1443	0.106	0.1634	0.099	0.0205	0.0443	0.1613	0.0859	1															
q19_a	0.1104	0.0822	0.0949	0.1533	0.0019	0.0202	0.1467	0.0534	0.1146	1														
q19_b	-0.0009	0.0754	0.0258	0.0579	0.0652	0.0676	0.1193	0.0785	0.1154	0.1288	1													
q19_c	0.0698	0.0694	0.0804	0.0375	0.0546	0.1355	0.1802	0.1204	0.1213	0.1958	0.2189	1												
q19_d	0.0635	0.0664	0.0394	0.1484	0.0953	0.127	0.2144	0.0873	0.1117	0.1024	0.1277	0.1948	1											
q19_e	0.0918	0.0734	0.1967	0.1562	0.0681	0.0214	0.1743	0.1164	0.146	0.1658	0.1523	0.1914	0.3447	1										
q19_f	0.1567	0.0723	0.0924	0.0983	0.0891	0.0878	0.1574	0.0995	0.1058	0.0581	0.1283	0.1916	0.259	0.2662	1									
d1dm	0.0989	0.0808	-0.0042	0.1602	0.1447	0.2065	0.2628	0.1305	0.039	0.1706	0.0919	0.2207	0.2291	0.1305	0.1194	1								
d4dm	0.0582	0.0585	0.1167	0.029	0.0436	0.0547	0.1506	0.0747	-0.0228	0.1381	-0.1008	0.0763	0.1441	0.1962	0.0438	0.1986	1							
q22_1	0.1278	0.0508	0.0239	0.1859	0.1318	0.0496	0.1194	-0.0263	0.0532	0.1431	-0.0329	0.074	0.106	0.08	0.0813	0.1008	0.0632	1						
q22_2	0.1571	0.0189	0.0237	0.0966	0.182	0.1632	0.085	0.0466	0.1155	0.077	0.091	0.1141	0.0945	0.0954	0.0975	0.1947	-0.0032	-0.1038	1					
q22_3	0.0884	0.058	0.0141	-0.0242	0.1131	0.1746	0.1046	0.0128	0.0522	-0.0163	0.3025	0.0843	0.0385	0.0153	0.0029	0.0507	-0.1158	-0.094	0.1909	1				
q11_2	0.3266	0.0704	0.0375	0.1015	0.1078	0.1997	0.1083	0.0863	0.1207	0.039	0.0566	0.0577	0.1125	0.0673	0.0882	0.0494	0.023	0.103	0.1302	0.1349	1			
q11_3	0.2046	-0.0079	0.0024	0.0901	0.0886	0.1277	0.0529	0.0475	0.0257	-0.0086	0.0816	0.0566	0.1144	0.0575	0.159	0.0425	-0.0199	0.0983	0.0597	0.0926	0.2307	1		
q20_3	0.2001	-0.0118	-0.0844	0.0244	0.1628	0.3048	0.0909	0.069	-0.0204	0.0537	-0.0136	0.0896	0.076	-0.0561	0.0273	0.1793	0.0367	0.1117	0.1155	0.1037	0.1076	0.1248	1	
countinnc	0.1208	0.0337	0.0251	0.2212	0.0172	0.0455	0.249	-0.0047	0.0663	0.1516	0.0232	0.0587	0.1437	0.1358	0.0199	0.2183	0.1271	0.1873	0.0707	-0.0361	0.1583	0.0685	0.0367	1

Figure 3 – Dendrogram for a cluster solution based on Ward’s linkages, truncated to show only 15 groups

