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Public procurement for innovation: lessons from the procurement of a navigable storm surge barrier

Joeri H. Wesseling (joeri.wesseling@circle.lu.se)
CIRCLE, Lund University

Charles Edquist (charles.edquist@circle.lu.se)
CIRCLE, Lund University

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Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

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JEL codes: O30, O31, O32, O33, O38, H54, H57

Keywords: innovation policy; demand-side policy; large infrastructural project; tender; water construction sector

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Public Procurement for Innovation (PPI) is a powerful, underutilized demand-side innovation policy instrument that can be used to stimulate innovation, meet sectoral policy goals and mitigate grand challenges. Further research is required to analyze how PPI contributes to these goals and how it operates in practice; more case studies are needed to achieve this. We analyze a case of direct developmental PPI, the procurement of a navigable storm surge barrier in the Netherlands. Data from policy documents, reports and interviews were used in an event history analysis which serves to capture dynamic patterns of innovation activities. We interpret our findings in relation to the tentative lessons on PPI available in the literature. We also draw policy conclusions with respect to dealing with multiple policy goals and user needs; specifying functional requirements; levels of expertise within governments; balancing competition and cooperation; and taking risks.

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1. Introduction

Public Procurement for Innovation (PPI) is a powerful, underutilized demand-side innovation policy instrument that can be used to stimulate innovation, meet sectoral policy goals and mitigate grand challenges (Edler and Boon, 2015; Edler and Georghiou, 2007; Edquist, 2015; Edquist and Zabala, 2012). PPI "takes place when a public agency or unit places an order for a product (good, service or system) to fulfil certain functions within a given time period, but which does not exist at the time of the order" (Edquist, 2015, p.7). It is the demand-pull for the commercial application of new solutions that makes PPI so powerful (Edler and Georghiou, 2007).

PPI can be applied for different policy purposes (Edler and Boon, 2015; Edquist and Zabala, 2012; Edquist, 2015; Edler and Georghiou, 2007). PPI can be used to achieve sectoral or public agency-specific policy goals such as enhanced transport or energy infrastructure; it can also be used to boost innovative performance by providing better demand conditions (Edler and Boon, 2015); and it can be used to help mitigate grand societal challenges and pursue mission-oriented policies (Edquist and Zabala, 2012; Edler and Georghiou, 2007; Aho et al. 2006; Edler and Boon, 2015). Further research is needed to understand how policy makers can direct the PPI process so that the ensuing innovation achieves one or more of these purposes (Boon and Edler, 2015).

To gain such understanding, the currently available tentative lessons on PPI need to be further developed. Empirical analyses of PPI are so far limited to case studies in various sectors and countries, but more systematic analyses are lacking (Edler 2009; Edler et al. 2005; Edquist & Zabala-Iturriagagoitia 2012; Flanagan et al. 2011; Hommen & Rolfstam 2009; Uyarra & Flanagan 2010). More case studies need to be conducted with systematic methods of data collection to enable systematic comparisons. The tentative lessons for policy makers to organize PPI that result from this body of literature include the following.

- Related to the plurality of policy goals behind PPI mentioned before, *the identification of user needs* is key in the early phase of PPI. "One of the greatest challenges … is to reconcile the expectations, needs and limitations of a large number of users" (Edler et al., 2006, p.9).
- The *specification of functional requirements* of the innovation that is to be procured is crucial. These should not be too narrow to stimulate creativity and technological variety (Edler et al., 2006; Edquist and Zabala, 2012; Edquist, 2015; Uyarra et al., 2014).
- It is important to *develop expertise within procuring public agencies* to manage/coordinate the PPI process and to make assessments of the solutions proposed by suppliers (Edler et al. 2005; Edquist 2015; Uyarra et al. 2014).
- *Finding a balance between cooperation and competition is key.* Cooperation amongst buyers and suppliers stimulates learning by interacting but reduces technological variety as well competition between buyers (Edler et al., 2006; Homman and Rolfstam, 2009; Edquist and Zabala, 2012).
- PPI takes time and may fail. Procurers should be aware of this and be able to *take and manage the risks* that are typical to the procuring of products that do not yet exist at the time of procurement (Edler et al., 2015; Edquist, 2015; Georghiou et al., 2014).

Through this case study, we aim to further develop these lessons for policy makers to enable them to manage PPI processes in ways that make them successful in meeting their (plurality of) policy goals.

Several PPI taxonomies have been developed (e.g. Edquist and Hommen, 2000; Hommen and Rolfstam, 2009; Edler and Georghiou, 2007; Edquist and Zabala, 2012; Edquist, 2015). What these taxonomies have in common is that they distinguish between the user of PPI and the character of the innovation procured. When the procuring organization is also the end user of the procured innovation, or is responsible for the societal function that is achieved through the innovation, we may speak of *direct PPI*. Contrarily, when the procuring agency serves merely as a catalyst, coordinator and resource to procure innovation on behalf of the end-user, we can speak of *catalytic PPI*[1]. Finally, we may also distinguish between *adaptive PPI*, which is public procurement for a product that requires only incremental adaptation before implementation, and *developmental PPI,* which demands a completely new product and consequently requires intense R&D efforts before implementation.

This paper analyzes in-depth a case of direct developmental PPI that is driven by multiple policy goals and where a long-term contract is rewarded through a multi-stage selection process. This case enables us to study how policy makers have directed a PPI process in ways that yield innovations that combine multiple policy goals. This approach enables a deeper understanding of the directionality in PPI driven by different types of policy rationales. We structure our analysis using the currently available tentative lessons on PPI summarized in this section.

2. Case study description

The case study focuses on the public procurement of a navigable storm surge barrier (NSSB) in the New Waterway, the Netherlands (1987-1997). In 1987 the Dutch public agency responsible for water safety, 'Rijkswaterstaat', issued a tender for a radically new solution to protect the Netherlands from storm surges, but that did not hamper shipping through the New Waterway to sustain the competitiveness of the Rotterdam main port. The functional requirements constituted an unprecedented advanced demand that made existing NSSB technologies technically insufficient (Arcadis 2006; Environment Agency 2009). Hence, we study a case of developmental PPI.

The innovation that emerged, the 'Maeslantkering' comprises two pivoting steel floating sector gates (CSW 1987), was new to the world and has since only been implemented in the St. Petersburg barrier (Dircke et al. 2012; Hunter 2012). This means that the lead user role that public agencies can play through PPI (Edler and Georghiou, 2007) is limited in this case because the specificity of the solution meant there was no larger market. The PPI studied is therefore clearly linked to societal challenges that fall under the responsibility of a public agency, implying we study a case of direct, developmental PPI.

The PPI process involved a design-construct-maintain contract, which was awarded after a pre-qualification stage and three rounds of competition. Six consortia (comprising 33 firms) signed in for the tender, of which one was excluded during the pre-qualification stage. The first round of competition lasted three months during which the five remaining consortia competed with six

[1] Some scholars also separate out cooperative PPI in somewhat different senses (Edler and Georghiou, 2007; Edquist and Hommen, 1999; Hommen and Rolfstam, 2009) in which public and private purchasers pool their demand for the innovation or there may be considerable cooperation between procurers and (potential) suppliers in some stages of the procurement process.

designs. During the subsequent three-month round, four consortia competed with five designs, while during the third round, lasting two months, only two consortia competed with one design each. The winning consortium (BMK) spent two years to develop a “build design”, seven years to construct the navigable barrier which opened in 1997, and was responsible for five years of maintenance. The government paid 960 million guilders (436 million euro’s) for the barrier (Verkeer and Waterstaat 1998).

This case study is unique because it was the first time the design for such an innovation was not developed by the public agency. This means that the agency had significant expertise in-house, while lack of public expertise is often identified as a bottleneck to PPI (Edler et al., 2006; Edquist, 2015). The PPI process was characterized by some organizational mistakes and successes that we can draw important lessons from. The water construction sector has, furthermore, not yet been studied from a PPI perspective and unique because the failure of an innovation may result in tremendous societal costs (e.g. with flooding) that cannot be carried by the private sector. Application to this sector may provide new lessons for PPI. Finally, the PPI can be considered a success, because the ensuing innovation enabled the public agency to optimally meet its policy goals.

3. Methods

Since the literature on PPI is relatively immature, only limited amounts of systematic data exists and few systematic methods for data collection have been devised. One exception is a survey on procurement, partly also covering PPI, that has been carried out by Georghiou et al. (2014) and Uyarra et al. (2014).

In this case study, the development of the PPI process was captured through event history analysis, which allows for the identification of causal mechanisms in the innovation process. Event history analysis can also capture dynamic patterns of innovation activities and has been used to study innovation processes at both the micro and meso level (Hekkert et al. 2007; Van de Ven et al. 1999). These characteristics make case studies a very useful tool to study directionality in the PPI process and to identify policy recommendations.

Our database comprised the public agency’s extensive documentation of the PPI process as well as complementary technical journals and reports. To triangulate these data and collect data on processes not captured by formal documents, interviews with eleven stakeholders were conducted. All relevant stakeholders were interviewed, including the project leaders and managers of the PPI project, throughout every stage of the PPI and from both the public (7) and private side (4). This paper builds on a 107 page report, that also includes the list of interviewees; please consult Wesseling et al. (2010) for more information.

4. Results and analysis

In this section we describe and analyze the case study of PPI for a NSSB in the New Waterway over the period 1987-1997. This section is structured along the lessons on PPI that were identified in previous literature.

1. Dealing with multiple policy goals and user needs

The public procurement for a NSSB in the New Waterway resulted from the urgent societal need for water safety, which became apparent by the 1953 storm surge were nearly 2000 citizens drowned (CSW 1987; De Groot 1995; Schot et al. 1998). The public agency Rijkswaterstaat organized the PPI as it is responsible for water safety in the Netherlands. At the same time, the Rotterdam harbor had developed its vision to become a European main port and to support this vision, Rijkswaterstaat had to procure a solution that would not hamper shipping.

To maintain support for the PPI, local public and private parties could voice their needs to a dedicated commission which also continuously informed these parties about the progress of the PPI. The public was however allowed no voice in the decision making process, as extensive technical knowledge is required to support such a decision (Hoogland, 2010). Additionally, a commission for environmental effects was instated as part of the broader PPI organization to prevent environmental concerns. The initiation, selection and implementation of the PPI were furthermore subject to parliamentary vote.

The PPI related to two broader societal challenges. First, the policy documents indicated that demand for water safety was related to the societal challenge of sustainability, as global warming leads to rising sea levels and an increased threat of storm surges (Van Oorschot & Pruijssers 1995). Hence, the PPI aims to remedy the effects (but not the cause) of unsustainability. Second, the PPI had to support the European main-port vision that would address the societal challenge of economic competitiveness by providing an excellent shipping infrastructure (Interviewee 7; CSW, 1987).

From an innovation policy perspective, this PPI has significantly enhanced the innovative performance of various organizations involved, but this translated into little economic gain. Although the iconic project has resulted in expertise, valuable networks and reputational benefits, the specificity of the project and protectionist foreign policies prevented the supplier from winning similar design and construct projects (Interviewees 8-11). To conclude, the PPI was successful in meeting the agency-specific goals that related to broader societal challenges, but was not inspired, nor deemed successful from a wider innovation policy point of view, including widespread diffusion.

2. Specifying functional requirements

The success of the PPI in meeting its policy goals lies for a large part in the formulation of its functional requirements (Interviewees 3,4,5,8). Before specifying functional requirements, the public agency introduced a pre-qualification round during which competing consortia were assessed based on their financial means, production capacity and experience (Interviewee 8). Subsequently, the initial functional requirements were set; the demanded 1) a reduction of the normative high water levels of 1.6m by Rotterdam and 0.4 to 0.6m by Dordrecht; 2) all designs must apply to the indicated 6 km region of the New Waterway; 3) a passage breadth of 360m; 4) an unlimited passage height; 5) a threshold depth of -17.0m below sea level. These requirements included the different user needs and policy goals, resulting in an unprecedentedly advanced demand that made existing NSSB designs technically insufficient (Arcadis, 2006; Environmental Agency, 2009). Its broad formulation nevertheless succeeded in facilitating creativity and enabling a broad range of solutions.

Because too little information on the feasibility of the radically new solutions was available to make a substantiated selection, additional specifications of the functional requirements and selection rounds were unexpectedly planned twice. During these subsequent selection rounds Rijkswaterstaat commissioned technical and techno-economic analyses on the basis of which they set increasingly specific functional requirements and posed specific questions about the feasibility of the design (CSW and RWS 1988; CSW 1987).This iterative process enabled the PPI commission to specify ad hoc the requirements that emerged as important throughout the tender process. This process led to the selection of a safe, technically feasible, easy to maintain solution, that had an acceptable cost and that hampered shipping to an acceptable degree. The success of the approach is underlined by the interviewed public agents who indicated that this creative solution could never have been built by the more conservative Rijkswaterstaat who used to be responsible for storm surge barrier design (Interviewees 2, 3, 4, 5, 6).

3. Expertise within public agencies

To oversee the PPI, an extensive organization was set up, comprising six workgroups, a coordination group, a steering group, a test group and the PPI commission that reported to the minister (CSW; 1987; CSW and RWS, 1988). These groups comprised experts from different knowledge organizations and public agencies that were selected to test the validity of the consortia's designs and select the best one, but also to provide legal and public support for installing the innovation/NSSB (*Ibid*.). The groups were also responsible for developing a so called "shadow design" that would be constructed if the consortia would not provide high-quality solutions (Interviewees 2-8). The technical expertise was furthermore necessary to support the development of the winning design into a construction design. The organization's technical expertise served to shift the consortia's competitive focus from cost to more quality-oriented (Interviewees 3, 4). This quality orientation is particularly important since the societal and economic costs of a failing NSSB (i.e. large scale flooding) in this case would be extremely high and could not be carried by the consortia.

An important responsibility of the PPI's organization was also to coordinate the micro-level innovation system around the project. Regardless of the organization's expertise, they still needed to commission more than 20 studies by 7 different (hydrological, geological and engineering) knowledge institutes to validate and complement the consortia's designs. Throughout the entire PPI at least 60 studies were performed by over 15 organizations in total. Commissioning, interpreting and connecting these studies demands extensive and broad knowledge of the PPI's organization.

4. Balancing competition and cooperation

During the selection stages of the tender process there was intense competition between the consortia. During the first selection round, five consortia had submitted six designs. Because the BMK consortium could not agree on the interpretation of the broad functional requirements, they split up in two fiercely competitive teams who each submitted their own design (Interviewees 8, 9). Two times did the procurer unexpectedly implement extra selection rounds, instead of appointing a winner. During these additional selection rounds, the remaining consortia were compensated for only a fraction (5-25%) of their actual costs (Interviewees 8-11). This was perceived as a trap because the unplanned additional selection stages drove the fiercely competitive consortia to invest more and more to legitimate their sunk costs and stay in the race for the contract (Interviewees 3, 4, 8, 9, 11).

The public agency was afraid that the consortia's solutions would converge as a result of knowledge sharing. Therefore, and to stimulate competition, they prohibited interaction between the PPI organization and the consortia during the first two selection stages to the PPI process (Interviewees 3, 4, 7, 8). There was however cooperation during the third selection stage, and particularly the build design and the construction stages (Interviewees 3, 4, 7, 8). The consortia cooperated not only with the PPI organization to exploit their expertise, but also commissioned numerous technical studies by expert organizations. Hence, this multi-stage PPI format seems to exploit a fruitful balance between competition during the early stages which enhanced technological variety (CSW, 1987), and cooperation during the later stages which optimized further development of the selected solution through complementary expertise and interactive learning by doing.

5. Taking risks

PPI always involves risk, because the procured product does not exist yet at the time of the order. However, in the case of the PPI for NSSB there was a small chance of extremely high societal and economic costs of a failing NSSB (i.e. large scale flooding). Because these risks cannot be carried by the private supplier and because private actors have a cost-cutting orientation that is incompatible with such risk, the government had to assume responsibility for the barrier (Interviewees 3, 4).

The minister wanted to sign the contract before the end of her term, but she had problems obtaining the 840 million guilder budget for the barrier and, ironically, made the mistake of hastily saving 30 million guilders on vertical valves that proved crucial to the design's stability (Interviewees 3, 4, 8, 9). The ensuing problems resulted in a year's delay of the construction process a 60 million guilder cost increase. This experience shows that when dealing with R&D-intensive developmental PPI, technical decision making power should remain with the experts to prevent uninformed, top-down cost-cutting decisions. Politicians should restrict themselves to providing the resources needed and to indicate in which general areas that innovation procurement and functional procurement could be an appropriate policy instrument. This is one reason why we refer to "public" procurement rather than "government" procurement.

One way of reducing the risk in the PPI was a strict monitoring procedure, where the public agency's experts had to validate the consortium's biannual progress reports. Furthermore, risks of high maintenance costs were somewhat mitigated by the design-construct-maintain contract which specified that the consortium had to carry the cost of maintenance during the first five years (Van Oorschot and Pruijssers, 1995).

5. Conclusion and policy recommendations

This study shows that it is possible for PPI to meet multiple sectoral policy goals, inspired by different societal challenges. We have provided insights into the directionality underlying the PPI process. Below we provide policy recommendations, based on the literature and enriched by our case study, that enable policy makers to successfully steer the innovation process in the direction of their (plurality of) policy goals.

1. Dealing with multiple policy goals and user needs. In this case PPI has successfully met sectoral policies on water safety and transport, which were inspired by different societal challenges of sustainability and of economic competitiveness respectively. To ensure valuable inputs to the selection process and to maintain support for such a multi-purpose PPI from all stakeholders, it is important that a well-structured PPI organization is set up. This structure should be an outlet for both public and private stakeholders to voice their concerns and should communicate the PPI's progress.

2. Specifying functional requirements. It is important for policy makers to anticipate that during developmental, R&D-intensive PPI, not enough information may be available to select a winning design after one stage. Therefore, policy makers should, in such cases, use multiple selection stages and specify this in advance so that potential suppliers can consider this in their decision to participate. During the first selection stage, functional requirements should be broad to stimulate creativity and enable a broad range of solutions. During the subsequent stages, functional requirements should iteratively become increasingly specific, using knowledge that is developed in response and parallel to the solutions proposed by the consortia, to facilitate further development. This combination enables the most informed selection of the best solution.

3. Expertise within public agencies. Setting functional requirements, assessing solutions, demanding the right information and coordinating the PPI process requires both in-depth and broad technical expertise. Particularly when multiple sectoral policy goals are pursued, expertise in all relevant fields is necessary. Such expertise can be commissioned externally, but private actors often have different priorities and risk perceptions than the public agency responsible for the PPI. It is therefore important for procuring organizations to develop such expertise in-house. For smaller organizations and because of tight budgets this may not be possible. Due to the enormous volume of public procurement – about 20 percent of GDP in the EU (Edquist, 2015) – it might therefore be important to create a separate national organization that can develop and offer advice to procuring organizations, particularly on matters of innovation procurement and functional procurement.

Our case also illustrates that uninformed intervention by politicians in the PPI process can be damaging to its outcome. Technical decisions should therefore not be made by parliamentary vote or ministers, but by experts.

4. Balancing competition and cooperation. During a multi-stage PPI procedure, policy makers may strike a fruitful balance between competition during the early selection stages, which facilitates technological variety, and cooperation during the later stages which optimizes further development of the selected solution(s) through complementary expertise and learning by interacting. When adopting a competitive orientation on PPI to stimulate technological variety, it is particularly important to adopt broad functional requirements.

5. Taking risks. Innovation in the water construction sector is associated with high societal cost of a possible innovation failure due to flooding. When private actors have different risk perceptions or cannot finance the excessive costs of a failing innovation, public actors should carry the risk of the innovation. Hence, when public agencies are responsible for sectoral policies that are characterized by such (concrete) risks, they should carry more of the risk of innovation than in innovation policy and mission-oriented policies when this is not the case. Assessing societal risks requires in-house expertise and strict monitoring throughout the innovation process. High-level decision makers should acknowledge the risk that may be involved in cutting costs on the procured innovation.

In reflection on these policy recommendations we find some interdependencies. It seems that expertise within public agencies is relevant to all other lessons on PPI. Particularly for developmental PPI, expertise is crucial to drafting the right functional requirements and to modify these over the successive tender stages as sufficient knowledge is not available at the outset of the procurement process. Moreover, expertise is key to assessing how the procured innovations contribute to the plurality of policy goals, how to combine these goals and how to manage a diverse array of stakeholders. Expertise is furthermore important to strike a good balance between competition and constructive, in-depth cooperation. Finally, in-house expertise is crucial to reliably assess the risks of innovation, which is particularly important in the water construction sector, where failure of the procured innovation spells disaster for society.

Research on innovation-related public procurement is still in an early stage of development and can therefore still profit from case-oriented research with an explanatory objective. However, further research on PPI should also focus on developing methods for creating more systematic data that would enable a deeper understanding of the dynamics and directionality of PPI processes, as was done by Georghiou et al. (2014) and Uyarra et al. (2014). This may result in more specific policy recommendations and may facilitate comparisons to improve the empirical basis for these recommendations.

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