Thuan, N., Antunes, P., & Johnstone, D. (2015). Establishing a Decision Tool for Business Process Crowdsourcing. In T. Dang, R. Wagner, J. Küng, N. Thoai, M. Takizawa, & E. Neuhold (Eds.). 2nd International Conference on Future Data and Security Engineering (FDSE). Ho Chi Minh City, Vietnam (Vol. 9446). Heidelberg: Springer.

Establishing a Decision Tool for Business Process Crowdsourcing

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Abstract. The integration of crowdsourcing in organisations fosters new managerial and business capabilities, especially regarding flexibility and agility of external human resources. However, a crowdsourcing project involves considering multiple contextual factors and choices and dealing with the novelty of the strategy, which makes managerial decisions difficult. This research addresses the problem by proposing a tool supporting business decision-makers in the establishment of crowdsourcing projects. The proposed tool is based on an extensive review of prior research in crowdsourcing and an ontology that standardises the fundamental crowdsourcing concepts, processes, dependencies, constraints, and managerial decisions. In particular, we discuss the architecture of the proposed tool and present two prototypes, one supporting what-if analysis and the other supporting detailed establishment of crowdsourcing processes.

Keywords: Business process crowdsourcing, crowdsourcing, decision support system, design science, ontology.

1 Introduction

Crowdsourcing is becoming a viable, popular business strategy for organisations, which can harness human power, wisdom, information, and ideas from the external crowd in a flexible way and a short period of deployment time [1, 2]. This popularity can be demonstrated by the increasing number of organisations adopting the crowdsourcing strategy and revenues brought by the crowdsourcing market. The list of organisations that successfully adopted crowdsourcing is long, including big companies like iStockPhoto, Amazon, Threadless, Colgate-Palmolive, Unilever, L'Oreal, Eli Lilly, Dell, and Netflix [1, 3]. Regarding market revenues, a recent report shows that the enterprise crowdsourcing market grew 53% in 2010, 75% in 2011, and was expected to double in 2012 [4]. Likewise, crowdsourcing has been expanding to different fields including software development [5], marketing [6] and hospitality [7].

As a response to this popularity, organisations are struggling to assimilate and standardise business processes around this strategy, a movement that has been coined Business Process Crowdsourcing (BPC) [8, 9]. BPC can be seen as *a traditional set of organisational activities done by crowdsourcing entities, plus the coordination of the entire business process*. By establishing BPC, organisations can integrate the crowdsourcing strategy with their day-to-day business processes, being "able to seamlessly bring together the crowd, individual actors, and the machine" [10]. Thus, it enables incorporating the crowdsourcing capabilities within the organisational value proposition [11].

Although the advantages of crowdsourcing to organisations have already been highlighted by several researchers [8, 12], only recently have there been noticeable efforts researching BPC [10, 11]. Even though they investigate the BPC phenomenon from different angles, these studies consistently suggest that, in the long run, BPC needs to be established as a continuous organisational process, which requires systematic management of the strategy. Aligning with these efforts, we have conducted a 3-year research project that focused on BPC from a managerial decision-making perspective. We started the project by reviewing the existing crowdsourcing literature and eliciting the main BPC concepts, activities and contextual factors. We then articulated all these elements into a decision framework consisting of three phases: decision to crowdsource, process design, and system configuration [9].

Based on this framework, the project then investigated how to support managerial decisions in each phase. More precisely, we articulated the several factors, relationships, decision choices, and recommendations suggested by existing literature in the decision framework. In this way, the project analysed and conceptualised the decision to crowdsource [13] and the various design and configuration options [9]. Besides conceptualisation, we have also developed a more formal BPC ontology, which consists of more than 100 domain concepts, relationships and rules [11]. The ontology itself highlights the complexity inherent in establishing a BPC process.

The next logical step in our research consists of helping decision makers—project managers, business analysts, and process designers—making analytical decisions in the crowdsourcing establishment. This type of support is within the typical domain of Decision Support Systems (DSSs) [14, 15]. As a part of our research project, the current study aims specifically at developing a decision tool supporting the establishment of BPC. Given the above discussion, the tool should be beneficial by supporting managers on not only the decision to crowdsource or not [13], but also the various inconspicuous decisions that follow the decision to crowdsource, which include design and configuration issues [10]. Building on the BPC ontology, the tool emphasises strategic decisions, extending the managers' capability to make informed decisions about the entire BPC process.

Considering the impact of Design Science on DSSs [14], our study follows a Design Science paradigm [16, 17]. In particular, this paper reports the development of a crowdsourcing decision tool, viewed as a design artefact. To provide a solid knowledge base for building this artefact, the study relies upon the BPC ontology previously developed by the project [11]. This knowledge base is integrated with the tool's architecture. By doing so, the tool consolidates existing research knowledge in a structured decision-making process.

By doing so, the current study should benefit both practitioners and academics. From a practical point of view, the study provides a computer-based tool supporting organisations in establishing crowdsourcing strategies. From an academic point of view, the tool investigates the establishment of BPC at the concrete decision level, and thus complements prior conceptual efforts [11, 18]. Furthermore, since the tool is based on a BPC ontology [11], its development responds to the call for a more integrated and holistic view on crowdsourcing research [19, 20].

2 Literature Review

2.1 Identification of Problems

The concept of crowdsourcing was first introduced by Howe [2] in 2006. By that time, researchers discussed and explored what the concept means and its potential applications [6, 19]. These efforts contributed to an initial conceptualisation of crowdsourcing, usually referred to as a process utilising the members of the crowd and the Internet with the purpose to fulfil ad hoc tasks. They also discussed the application of crowdsourcing strategies in several areas including information processing, idea gathering, design [21, 22], and supporting decision making [23].

From an organisational point of view, crowdsourcing may consist of regular activities performed by internal employees and ad hoc activities performed by the external crowd [1]. Thus, there is a need to seamlessly integrate these activities into an organisational workflow or BPC [8, 9]. Such integration helps organisations become more efficient, as pointed out by Tranquillini et al. [10]. By integrating crowdsourcing processes in existing business processes, they can be built on top of existing business process management (BPM) technology and information systems [10]. Furthermore, this integration helps crowdsourcing to become a more mature technology for organisations to exploit [24, 25].

However, the establishment of BPC is not a straightforward task. The existing literature highlights several issues and challenges related to this establishment [5, 22]. For instance, Djelassi and Decoopman [22] suggested that it is not a simple, but a rather complex process. These authors viewed the process as requiring the coordination of several business components, including infrastructure, incentive mechanisms, the crowd, customers, and also the financial viability. In a similar vein, Tranquillini et al. [10] identified a variety of options and configurations for BPC integration. Recently, Thuan et al. [11] synthesised the components, processes, activities, and data entities necessary for this integration from an ontological point of view. They noted the diversity of related concepts, hierarchical relationships, decision-making relationships, and business rules related to BPC. Given this complexity, a critical challenge is how to help organisations establishing BPC.

DSSs help organisations making decisions about wicked problems like BPC. In the crowdsourcing field, a few exploratory DSSs have been developed. Geiger et al. [20] proposed a foundation for constructing a recommendation system matching individuals in the crowd with types of crowdsourcing tasks. Recently, Prokesch and Wohlenberg [26] developed a DSS that processes results from the crowd. Although these systems can support certain aspects of crowdsourcing, they are mainly focused on very specific functions like task assignment [20] and results aggregation [26], rather than the whole integrated process. Consequently, there is still a need for a DSS tool supporting the entire BPC process. From the discussion in this section and the introductory section, we note that such tools should accomplish the following requirements:

- Assist managers deciding how to establish a BPC strategy or not. This assistance should be given as guidelines and recommendations.
- Build a comprehensive, integrated view of BPC. In other words, the tool should support the integrated BPC process, not individual activities. Several DSS studies suggest that such an integrated view can be achieved by using sound domain ontologies [27].
- Support micro-decisions related to the BPC process, including process design and configuration. Within each component, the (sub) issues, their alternatives and guidance to choose among these alternatives should be specified.
- Provide a means for the effective processing and presenting of knowledge related to the establishment of BPC.

2.2 DSS View

Decision Support Systems is a research area with a long history in Information Systems (IS), which can be traced back to Simon's intelligence-design-choice model developed in 1960 [15]. In this research area, the focus is on supporting and improving decision-making for wicked, normally semi-structured and unstructured decisions [14]. The term 'support' is important in DSSs, since these systems are not meant to replace decision makers, but help them extend their capabilities and make more informed, better decisions [15]. Normally, this support requires integrating domain models conceptualising the application domains, which helps decision makers to understand and explore different decision options.

Due to the long history, a large number of DSSs have been studied and developed in IS and its related fields for various endeavours [14, 28]. To structure these systems, several taxonomies have been proposed. Power [28] suggested five types of DSSs including data driven, model driven, knowledge driven, document driven, and communication driven, whose names reflects the main foundation backing the DSS. Recently, Arnott and Pervan [14, 29] analysed the DSS literature and developed a seven-type taxonomy, which was based on four dimensions: dominant technology, theory foundations, targeted users, and decision tasks. Using these dimensions, they suggested classifying DSSs into: 1) personal DSSs for individual managers; 2) group DSSs for a group of decision makers; 3) negotiation support systems, which are group support systems but involve negotiation functions; 4) intelligent DSSs, using artificial intelligence; 5) knowledge DSSs, which provide knowledge storage, retrieval, transfer, and application; 6) data warehousing, processing large-scale (big) data for decision support; and 7) enterprise reporting and analysis systems. Positioning our tool in these landscapes, we note our work is a personal model-driven DSS, since we focus on supporting independent managers and base the decision support on a BPC ontology.

Despite the variety of DSSs, the generic DSS architecture seems quite consistent. By and large, Holsapple [30] suggested four main DSS components: language component, presentation component, knowledge component, and problem-processing component. The language component processes user inputs. The problem-processing component tries to identify, analyse, and model the problem, which provides information, alternatives and advice for addressing the problem. This process is based on the knowledge component, which stores knowledge related to the problem. The output from the DSSs is presented to decision makers by the presentation component. Şeref and Ahuja [31] proposed a similar architecture grouping the language and presentation components into a graphical user interface (GUI), and divided the problem-processing component into model and database aspects. Since the components proposed by Holsapple [30] seem to clearly separate the major concerns, we adapted this schema to structure the proposed tool, which is discussed in Section 4.

3 Research Overview

The tool development follows the Design Science paradigm [16, 17], which has been adopted by many DSS developments. The links between DSSs and Design Science have been highlighted by prominent academics in both fields. In DSSs, Arnott and Pervan [32] argue that most DSS developments somehow correspond to what Hevner et al. [17] define as a design artefact. Even Hevner et al. [17] in their seminar paper demonstrated Design Science using three artefacts, of which two are DSSs. In Design Science, research mainly aims at developing artefacts solving wicked problems [16, 33]. Hevner and Chatterjee [16] demonstrate that development processes should be simultaneously relevant and rigorous. For the current study, while the tool's relevance has already been clarified and discussed in the literature review section, it is more challenging to fully demonstrate rigor.

Since crowdsourcing is an emerging field [1, 20], there are (at least) three challenges related to rigor. First, having recently conducted a review of crowdsourcing literature [9], we could not find a prevailing crowdsourcing theory that could be used as a rigorous knowledge base for development. Second, like other emerging and very dynamic research fields, different and sometimes conflicted findings can been found in the crowdsourcing research literature [20], which affects any attempts to fully justify every step of the tool development. These two challenges lead to the third one, which is related to the artefact's internal validity. More precisely, it is challenging to describe concepts formally and demonstrate logical assertions when a common understanding of BPC is still lacking, a dominant theory is missing, and the field is immature.

The current study addresses these challenges from two perspectives: a knowledge base perspective and a software development perspective. Regarding the former, we recognise that further consolidation of domain knowledge is necessary. Multiple researchers have suggested that domain ontologies help with constructing and consolidating domain knowledge [34, 35]. More precisely, they posit that, as conceptual modelling techniques, ontologies may formalise the domain and ease communication among different parties [36, 37]. While agreeing with these, we suggest also considering ontologies in the context of DSSs. In DSSs, Miah and von Hellens [27] used ontologies as knowledge components for "structuring and representing problem specific knowledge into a knowledge repository". Aligning with these authors, we developed our tool based on a BPC ontology [11].

From the software development perspective, an appropriate software development method is necessary to deal with the immature nature of the field. The current study follows Lim et al.'s [38] suggestion to adopt a rapid prototyping method. This method deals with complexity through iterative development and revision of a few prototypes [39], and allows traversing the tool's design space [38]. Prototyping is appropriate for DSS development, as suggested by Miah et al. [40] regarding the development of an expert system supporting rural business operators, and Antunes et al. [41] regarding the development of a decision tool supporting geo-collaboration.

In short, the ontological approach and prototyping method both help with consolidating the domain knowledge and iteratively understanding and developing the tool. These two perspectives are further detailed in the following sections, where we describe the tool's architecture and development details.

4 Tool Architecture

The tool's architecture is based on the components proposed by Holsapple [30] (Literature Review section). As shown in Fig. 1, the architecture has three main components: GUI, problem processing component, and knowledge component. The GUI component enhances the interaction between the tool and its users, i.e. managers and process designers, who make decisions on adopting and designing BPC processes. This component accepts parameters from the users. It also helps validating them by providing explanations about the parameters drawn from the domain knowledge and ontology. These inputs are processed by the problem process component, where parameters are used to formulate the problem and the associated context. Furthermore, the problem process component controls input flows by choosing and adapting what elements the GUI presents. It also manipulates data entries based on the knowledge component.

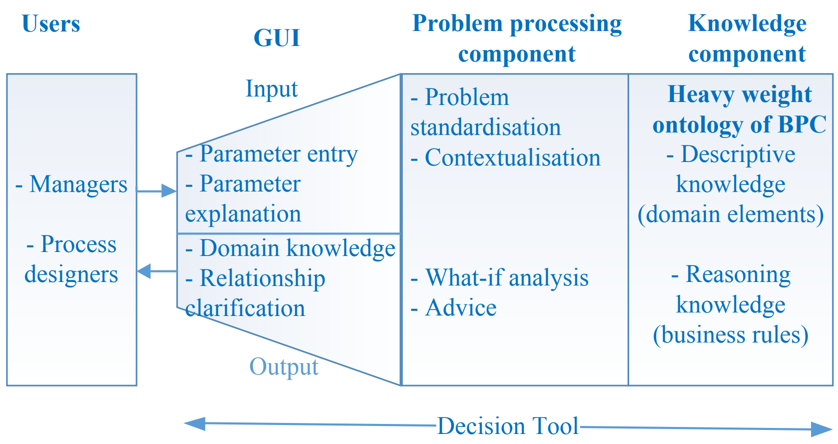

Fig. 1. Tool's architecture (adapted from [30])

The knowledge component adopts an ontology built in our previous research. Fig. 2 presents a lightweight view of the BPC ontology. The heavyweight ontology and its details can be found in [11]. As presented in Fig. 2, the knowledge component consists of descriptive and reasoning knowledge. Regarding descriptive knowledge, it provides definitions and descriptions of concepts that have to be considered in the decision-making process. It also includes a hierarchy of relationships among the (sub) concepts (presented as 'include' and 'categorise' relationships in Fig. 2). Reasoning knowledge provides business rules constraining these ontological elements.

Using the knowledge component, decision-makers can perform what-if analysis by comparing the knowledge specified by the ontology with the expressed input parameters. In this way, the ontology serves as a knowledge base capturing the basic profiles of crowdsourcing projects, which can be adapted based on project conditions and intervention plans. Through this adaption, the decision tool can detect ontological inconsistencies in the available data of the crowdsourcing project. As a result, it provides advice on how to set up a crowdsourcing strategy for a particular organisational context, and configure the process details, which in turn are presented as GUI's outputs.

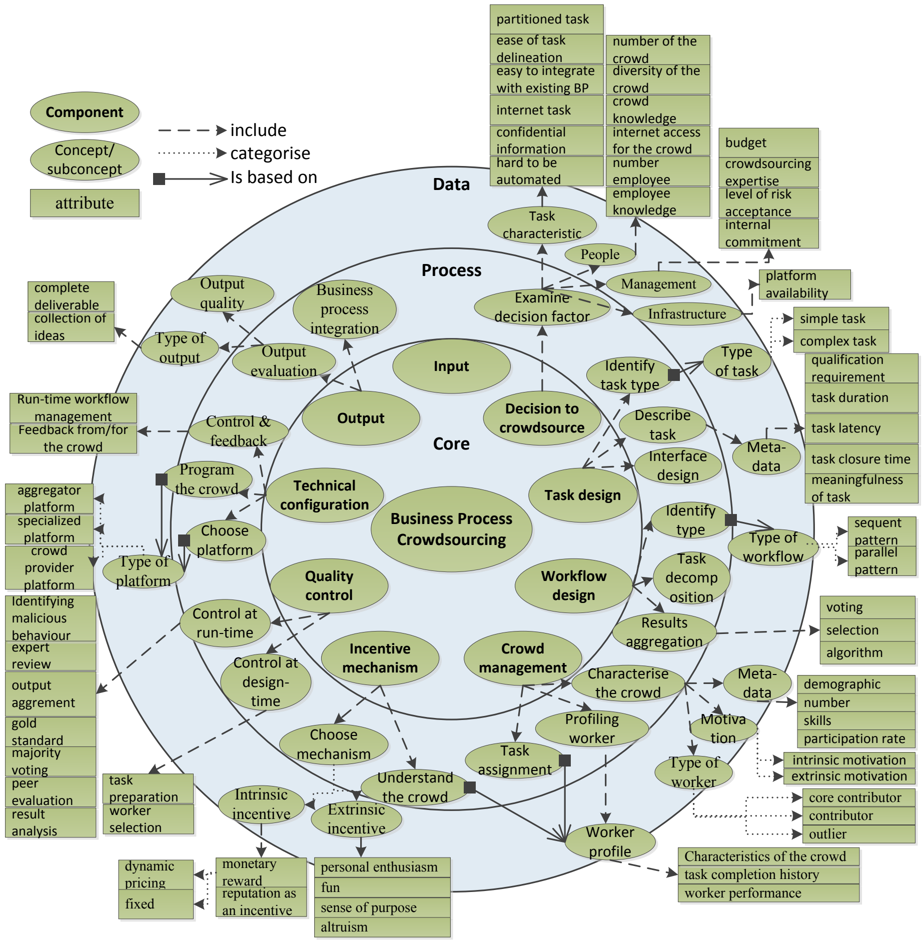

Fig. 2. A lightweight ontology of BPC [11]

5 Tool Development

Following the rapid prototyping method, tool development consisted of two phases: spreadsheet-based DSS and web-based DSS. The spreadsheet development demonstrates domain knowledge articulation, transferring knowledge drawn from the ontology into computer-based formulations. Şeref and Ahuja [31] suggest that spreadsheets are useful tools for modelling and developing DSS. Fig. 3 shows the spreadsheet component supporting the decision to crowdsource or not. In spite of visual austerity, the prototype implements all three architectural components. A question and answer section gathers parameters about the BPC organisational context. These parameters are then processed and transferred to a back-end sheet where the ontology elements are applied. This back-end sheet implements the knowledge component. After knowledge processing, several recommendations are provided by the tool (the 'Advice' area in Fig. 3). Besides Fig. 3, the spreadsheet tool also has another sheet that supports BPC process design and configuration.

#	Decision category	Decision factor	Questions	Answer
1	Task	Internet vs. Physical	The task and its input/output can be delivered amd collected through the internet	O
2		Integration with existing BP	Crowdsourcing could be integrated with the existing organisational business processes	O
3		Interactive	The task requires frequent interaction and communication between the organisation and the crowd, or between the members of the crowd	X
4		Delineation	The crowdsourcing task should be well-defined	X
5		Confidential information	The task includes confidential information, including privacy and intellectual property considertation	O
6		Particionable	The task can be partitionable into smaller pieces of work	
7	People	The crowd for task	There are high numbers of crowd members for perform crowdsourcing tasks	
8		Employee for task	The organisation/project has too few internal employees to deploy the task	
9	Management	Budget	Bugbet allocated for the crowdsourcing project is sufficient	
10		Crowdsourcing experts	The organisation/project has approriate expertise and experience to coordinate the crowdsourcing activities	
11		Level of risk acceptance	The organisation has high level of acceptance related to risks, e.g. low quality results and loss of intellectual property	
12		Internal commiment	Internal emploees have low commitment to crowdsourcing	
13	Environment	Platform	There are high availability of crowdsourcing platforms that can deploy the crowdsourcing activities	

Advice	Crowdsourcing task with additional actions: - Clearly define task in the latter stages of the crowdsourcing process - Define tasks hiding confidential information.

Fig. 3. Spreadsheet-based tool on the decision to crowdsource

Using this spreadsheet, we performed several what-if analyses generating a range of probable outcomes of the BPC project. This type of analysis allowed us to review and adjust the ontology implementation. Of course this prototype had its own disadvantages, especially regarding the limited utilisation of the knowledge base, and in particular the difficulties navigating between the decision to crowdsource and BPC design and configuration. The web-based prototype addresses these concerns.

5.1 Web-based Prototyping

The web-based prototype was developed as an improved and revised version of the spreadsheet prototype. This prototype, which was implemented using Php and MySQL, provides wider access to the knowledge base. The entity-relationship model (implemented with MySQL) enables more systematic information management. Furthermore, data structures were added to support project management. For instance, a user can create multiple BPC projects, each of which supports a particular organisational context and a particular phase of BPC. The database structure is presented in Fig. 4.

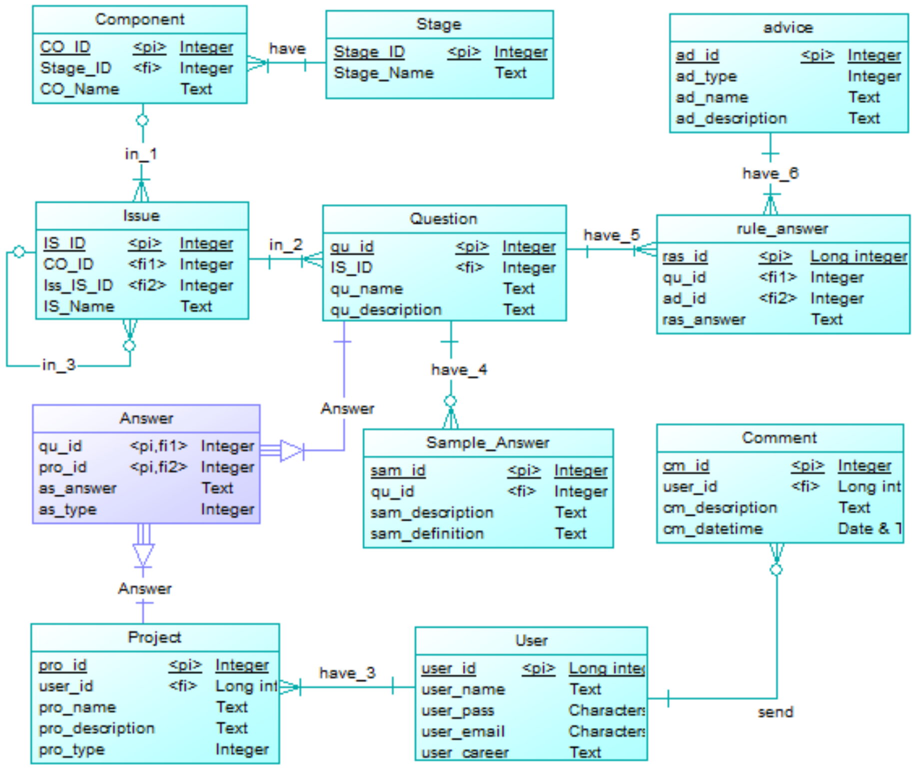

Fig. 4. Data structure of the web-based prototype

The prototype consists of two decision functions, supporting the decision to crowdsource (Fig. 5) and design process of BPC establishment (Fig. 6). More precisely, the former provides a check list of decision factors and analytical advice on making the decision to crowdsource. The latter specifies the design process of BPC, which helps to organise its establishment in an appropriate structure. To keep the prototype consistent, the user-interfaces of the two functions are consistently designed and organised in five areas (Fig. 5 and Fig. 6). The right-hand-side is dedicated to provide an overview of the decision to crowdsource and BPC design process. The left-hand side is divided into four areas with inputs and outputs. In the input area, the tool allows users to choose a design issue. After choosing a particular issue, an explanation and a pre-defined parameter are presented. If the user changes the parameter, advice will be provided. This prototype is currently being tested.

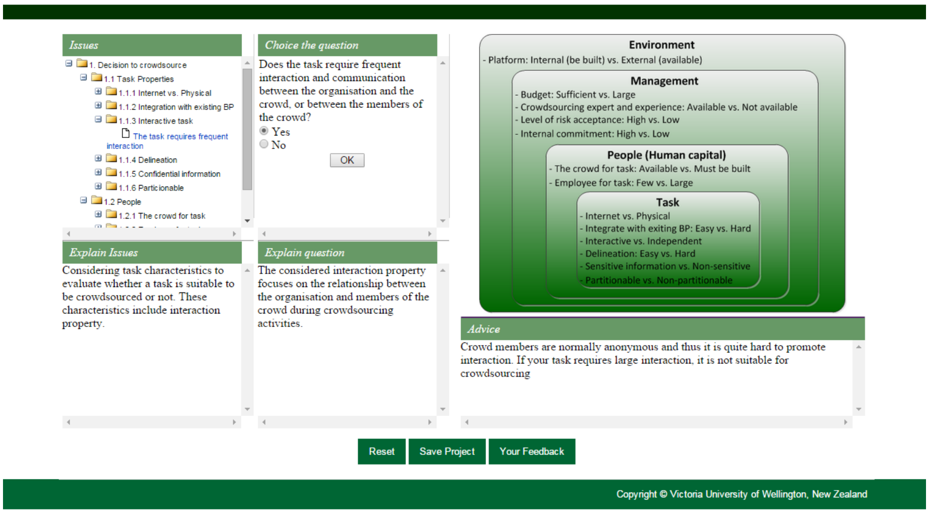

Fig. 5. A web-based tool: a screenshot on the decision to crowdsource

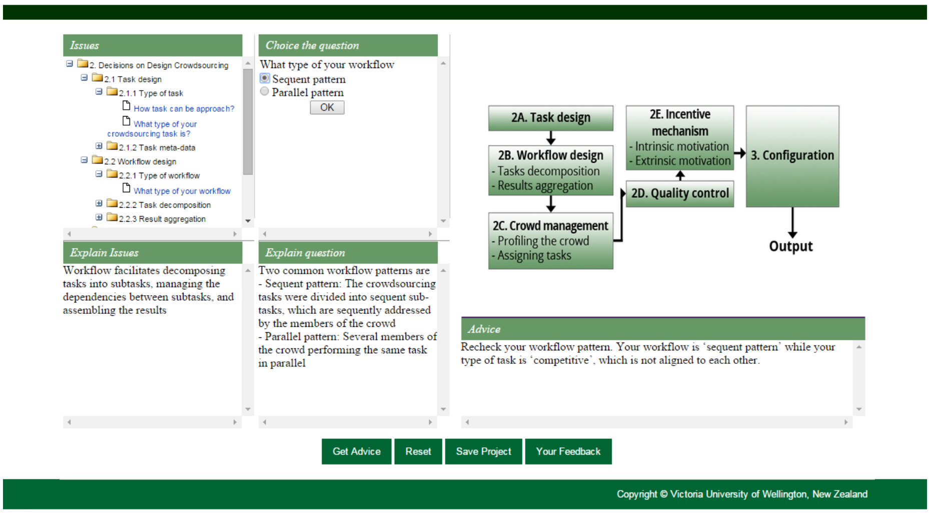

Fig. 6. A web-based tool: a screenshot on the process design of BPC establishment

6 Discussion and Conclusion

DSSs may help organisations adopting and configuring novel, complex business processes like crowdsourcing. Adopting the Design Science paradigm, this study developed a DSS supporting managers addressing the complexity of BPC projects [8, 12, 42]. Unlike the existing decision tools in the crowdsourcing domain [20, 26], which focus on individual aspects of BPC, the current study adopted an ontological approach for developing the DSS. As a result, the developed tool can support the whole, integrated BPC project, from the decision to crowdsource or not to process design and configuration.

Considering the emerging nature of the field [1], which increases the complexity of developing such a tool (especially demonstrating rigor), a prototyping development method was chosen [39]. We developed the tool architecture consisting of three main components: GUI, information processing component, and knowledge component. This architecture was utilised in two prototype implementations: spreadsheet-based and web-based. While the spreadsheet-based prototype allowed us to experiment with several crowdsourcing scenarios and analysing the parameters and recommendations provided by the ontology, the web-prototype is targeted to project and business managers, and process designers, who make managerial decisions in organisational contexts. Thus, the two prototypes make complementary contributions to research and practice.

Our research contributes to the current knowledge by building a decision tool for BPC, and thus validating an ontology of BPC [11]. More precisely, it structures concepts, relationships, business rules, and what-if scenarios of BPC into two computer-based prototypes. From a Design Science perspective, implementing these prototypes is an evaluation form of the ontology [43], which demonstrates the applicability of the ontology. From a crowdsourcing research perspective, the prototypes can be seen as a further contribution to the conceptualisation and standardisation of BPC. Since the prototypes allow researchers to explore different BPC scenarios, they can also be used as a research tool.

In future work, we will involve managers in using the prototypes with the purpose to further validate the usefulness of the ontology and tool. We can also evaluate the tool by conducting experiments. In the experiments, participants may be asked to makes crowdsourcing decisions in specific scenarios. One group of participants will make decisions using the tool and the other will make decision without the tool. Comparing performance of the two groups can provide empirical evaluation on the tool. From a system development perspective, our prototypes may be integrated with the work by Tranquillini et al. [10], which considered more technical details about BPC implementation. Thus, another interesting research direction is to investigate how to connect the managerial and technical domains. This connection would provide a system supporting organisations from the time they decide to crowdsource until the time they instantiate a BPC process on a particular crowdsourcing platform.

Reference

1. Zhao, Y. and Q. Zhu, *Evaluation on crowdsourcing research: Current status and future direction.* Information Systems Frontiers, 2014. **16**(3): p. 417-434.
2. Howe, J., *The rise of crowdsourcing*, in *Wired Magazine 2006*. 2006, Dorsey Press. p. 1-4.
3. Rosen, P.A., *Crowdsourcing Lessons for Organizations.* Journal of Decision Systems, 2011. **20**(3): p. 309-324.
4. Massolution, *The Crowd in the Cloud: Exploring the Future of Outsourcing*. 2013, Massolution.

5. Zogaj, S., U. Bretschneider, and J.M. Leimeister, *Managing crowdsourced software testing: a case study based insight on the challenges of a crowdsourcing intermediary.* Journal of Business Economics, 2014. **84**(3): p. 375-405.
6. Whitla, P., *Crowdsourcing and its application in marketing activities.* Contemporary Management Research, 2009. **5**(1).
7. Brabham, D.C., et al., *Crowdsourcing Applications for Public Health.* American Journal of Preventive Medicine, 2014. **46**(2): p. 179-187.
8. Vecchia, G. and A. Cisternino, *Collaborative Workforce, Business Process Crowdsourcing as an Alternative of BPO*, in *ICWE2010. LNCS*, F. Daniel and F.M. Facca, Editors. 2010, Springer. p. 425-430.
9. Thuan, N.H., P. Antunes, and D. Johnstone, *Toward a Nexus Model Supporting the Establishment of Business Process Crowdsourcing*, in *FDSE 2014. LNCS*, T.K. Dang, et al., Editors. 2014, Springer, Heidelberg. p. 136–150.
10. Tranquillini, S., et al., *Modeling, Enacting, and Integrating Custom Crowdsourcing Processes.* ACM Transactions on the Web (TWEB), 2015. **9**(2): p. 7.
11. Thuan, N.H., et al., *Building an Enterprise Ontology of Business Process Crowdsourcing: A Design Science Approach.* PACIS 2015 Proceedings, 2015: p. Paper 112.
12. Khazankin, R., B. Satzger, and S. Dustdar, *Optimized execution of business processes on crowdsourcing platforms*, in *IEEE 8th International Conference on Collaborative Computing: Networking, Applications and Worksharing*. 2012: Pittsburgh, PA
13. Thuan, N.H., P. Antunes, and D. Johnstone, *Factors Influencing the Decision to Crowdsource: a Systematic Literature Review.* Information Systems Frontiers, 2015: p. 1-22.
14. Arnott, D. and G. Pervan, *A critical analysis of decision support systems research revisited: the rise of design science.* Journal of Information Technology, 2014. **29**(4): p. 269-293.
15. Hosack, B., et al., *A look toward the future: decision support systems research is alive and well.* Journal of the Association for Information Systems, 2012. **13**(5): p. 315-340.
16. Hevner, A. and S. Chatterjee, *Design Research in Information Systems: Theory and Practice. Integrated Series in Information Systems*, ed. R. Sharda and S. Voß. Vol. 22. 2010: Springer Berlin Heidelberg.
17. Hevner, A., et al., *Design science in information systems research.* MIS Quarterly, 2004. **28**(1): p. 75-105.
18. Hetmank, L., *Developing an Ontology for Enterprise Crowdsourcing*, in *Multikonferenz Wirtschaftsinformatik*. 2014: Paderborn. p. 1089-1100.
19. Estellés-Arolas, E. and F. González-Ladrón-de-Guevara, *Towards an integrated crowdsourcing definition.* Journal of Information science, 2012. **38**(2): p. 189-200.
20. Geiger, D. and M. Schader, *Personalized task recommendation in crowdsourcing information systems—Current state of the art.* Decision Support Systems, 2014. **65**: p. 3–16.
21. Leimeister, J.M., et al., *Leveraging Crowdsourcing: Activation-Supporting Components for IT-Based Ideas Competition.* Journal of Management Information Systems, 2009. **26**(1): p. 197-224.
22. Djelassi, S. and I. Decoopman, *Customers' participation in product development through crowdsourcing: Issues and implications.* Industrial Marketing Management, 2013. **42**(5): p. 683-692.
23. Chiu, C.-M., T.-P. Liang, and E. Turban, *What Can Crowdsourcing Do for Decision Support?* Decision Support Systems, 2014. **64**: p. 40–49.

24. McCormack, K., et al., *A global investigation of key turning points in business process maturity.* Business Process Management Journal, 2009. **15**(5): p. 792-815.
25. Van Looy, A., et al., *Choosing the right business process maturity model.* Information & Management, 2013. **50**(7): p. 466-488.
26. Prokesch, T. and H. Wohlenberg, *Results From A Group Wisdom Supporting System.* Proceedings of the European Conference on Information Systems (ECIS) 2014, 2014: p. Paper 7.
27. Miah, S., D. Kerr, and L. von Hellens, *A collective artefact design of decision support systems: design science research perspective.* Information Technology & People, 2014. **27**(3): p. 259-279.
28. Power, D.J., *Decision support systems: a historical overview*, in *Handbook on Decision Support Systems 1*. 2008, Springer. p. 121-140.
29. Arnott, D. and G. Pervan, *Eight key issues for the decision support systems discipline.* Decision Support Systems, 2008. **44**(3): p. 657-672.
30. Holsapple, C.W., *DSS architecture and types*, in *Handbook on Decision Support Systems 1*. 2008, Springer. p. 163-189.
31. Şeref, M.M. and R.K. Ahuja, *Spreadsheet-Based Decision Support Systems*, in *Handbook on Decision Support Systems 1*. 2008, Springer. p. 277-298.
32. Arnott, D. and G. Pervan, *Design science in decision support systems research: An assessment using the Hevner, March, Park, and Ram guidelines.* Journal of the Association for Information Systems, 2012. **13**(11): p. 923-949.
33. Pries-Heje, J. and R. Baskerville, *The design theory nexus.* MIS Quarterly, 2008. **32**(4): p. 731-755.
34. Osterwalder, A., *The business model ontology: A proposition in a design science approach*. 2004, Institut d'Informatique et Organisation. Lausanne, Switzerland, University of Lausanne, Ecole des Hautes Etudes Commerciales HEC.
35. Ostrowski, L., M. Helfert, and N. Gama, *Ontology engineering step in design science research methodology: a technique to gather and reuse knowledge.* Behaviour & Information Technology, 2014. **33**(5): p. 443-451.
36. Guarino, N., D. Oberle, and S. Staab, *What is an Ontology?*, in *Handbook on ontologies*, S. Staab and R. Studer, Editors. 2009, Springer. p. 1-17.
37. Valaski, J., A. Malucelli, and S. Reinehr, *Ontologies application in organizational learning: A literature review.* Expert Systems with Applications, 2012. **39**(8): p. 7555-7561.
38. Lim, Y.-K., E. Stolterman, and J. Tenenberg, *The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas.* ACM Transactions on Computer-Human Interaction (TOCHI), 2008. **15**(2).
39. Kordon, F., *An introduction to rapid system prototyping.* Software Engineering, IEEE Transactions on, 2002. **28**(9): p. 817-821.
40. Miah, S.J., D.V. Kerr, and J.G. Gammack, *A methodology to allow rural extension professionals to build target-specific expert systems for Australian rural business operators.* Expert Systems with Applications, 2009. **36**(1): p. 735-744.
41. Antunes, P., et al., *Integrating decision-making support in geocollaboration tools.* Group Decision and Negotiation, 2014. **23**(2): p. 211-233.
42. Vukovic, M. *Crowdsourcing for enterprises*. in *2009 World Conference on Services-I.* 2009. Los Angeles, CA: IEEE.
43. Peffers, K., et al., *Design science research evaluation*, in *Design Science Research in Information Systems. Advances in Theory and Practice*. 2012, Springer Berlin Heidelberg. p. 398-410.