What can crowdsourcing do for decision support?☆

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ABSTRACT

Crowdsourcing can be viewed as a method of distributing work to a large number of workers (the crowd) both inside and outside of an organization, for the purpose of improving decision making, completing cumbersome tasks, or co-creation of designs and other projects. Of the various applications of crowdsourcing, the one investigated in this paper is to support various phases of managerial decision-making and problem solving. To examine the research issues related to such support, we created a framework based on four major components of crowdsourcing: the task that is outsourced, the crowd which carries out the task, the crowdsourcing process, and the outcome evaluation. Each component is examined from the managerial, behavioral, and information technology aspects. This framework enables us to organize existing literature and identify key research issues. Suggested topics for future research are described.

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1. Introduction

Changes in the business environment, such as increased competition, the explosion of mobile work, and the need to make rapid decisions, have altered the nature of organizational decision making. To cope with such changes, companies are employing new models and tools. Crowdsourcing is one that has gained much attention recently.

Crowdsourcing is an umbrella term for a set of tools, approaches and concepts that deal with the process of outsourcing work (including seeking ideas) to a large and possibly unknown group of people (the crowd) usually external to the organization. The term, which was proposed by Howe [31], is gaining popularity and attracting the attention of DSS and IS researchers [68].

Crowdsourcing has many definitions and variations. Estellés-Arolas and González-Ladrón-deGuevara [26] consolidated 40 previous definitions and provided an eight-characteristic-based definition that includes the use of a crowd for problem solving. Crowdsourcing provides support for managerial decision making, problem solving, and opportunity exploiting. The crowd (contributors or solvers) generates ideas and may also be involved in analyzing and prioritizing proposed solutions to problems. Crowd members also may recommend one best alternative. The special properties of crowdsourcing tools and procedures can result in significant time and cost reductions and many other benefits to organizations (e.g., see [4]).

There are several other reasons for organizations (private, public, and government) to use crowdsourcing, notably: finding solutions to persistent and difficult (wicked) problems. Other reasons relate to organizations’ limited resources and capabilities, and the desire to concentrate on a core competency [57]. For example, organizations may not have the expertise, the time or the money to do certain work, so they outsource it.

Thus, some crowdsourcing activities directly support distributed problem solving, while others do it indirectly. Indeed, a large number of crowdsourcing applications deal with problem solving and managerial decision making [68]. Crowdsourcing is also used as a mass collaboration tool for solving wicked problems [52].

Organizations also use crowdsourcing as a participative management tool where customers, business partners and employees get a chance to contribute (e.g., via joint design or provisions of alternative solutions to problems). Finally, some believe that in certain circumstances, “two heads are better than one,” and a crowd can actually do a better job than individuals, small groups, or even experts.

Despite the potential benefits of crowdsourcing and the substantial growth in the areas of crowdfunding, microtasking, and some co-creation, there has been less progress in the areas directly related to research regarding support of managerial decision making. Furthermore, alongside the many success stories of crowdsourcing, there have been reports of unsuccessful implementations and adoption problems, which range from cost overruns to poor quality decisions (e.g., [3]). In fact, many are questioning the nature of the process, pointing out that in several of the reported success, solutions were actually derived by small groups or by a few experts and not by crowd members. Justification is difficult due to intangible benefits and some related legal and

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The term “crowdsourcing” was coined by Jeff Howe and Mark Robinson in a Wired magazine article [31]. It was defined as “the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call” [31]. Crowdsourcing is a business practice that means literally to outsource an activity to the crowd [31]. Howe [31,33] has classified the applications of crowdsourcing into the following four categories:

1. Collective intelligence (or wisdom of the crowd). People (in a crowd) solving problems and providing new insights and ideas leading to product, process, or service innovations (e.g., see [18]).
2. Crowd creation (or user-generated content). People creating various types of content and sharing it with others for free or for a small fee.
3. Crowd voting. People giving their opinion and ratings on ideas, products, or services, as well as parsing, evaluating, and filtering information presented to them.
4. Crowdfunding. This is a special model in which people can raise money for investment, donations, or for micro-lending of funds.

An additional type is microworking or microtasking. In this type of crowdsourcing, organizations assign small pieces of work (microtasks) to many workers. A well-known intermediary for this type is Amazon’s Mechanical Turk (see [18]).

A few other scholars have also intended to identify different types of crowdsourcing research. For example, Yuen et al. [67] conducted a literature survey on crowdsourcing and categorized those studies by their applications (voting systems, information sharing systems, games, or creative systems), algorithms, performances (user participation, quality management, and cheating detection) and datasets. Geiger et al. [27] provided a review on classifications of crowdsourcing approaches. They proposed a taxonomic framework for crowdsourcing processes that include four dimensions: pre-selection of contributors, accessibility of peer contributions, aggregation of contributions, and remuneration for contributions. The classification scheme focuses exclusively on an organizational perspective and on the mechanisms available to these organizations. Based on the empirical examination of over 100 crowdsourcing organizations and the analysis of key inter-organizational differences, Saxton et al. [56] then build a comprehensive taxonomy of nine distinct types of crowdsourcing models, including the intermediary model, citizen media production model, collaborative software development model, etc.

2.2. Concepts related to crowdsourcing

Although the term “crowdsourcing” is relatively new, the concept was derived from the general trend that information technology allows ideas and efforts to be openly shared over the Internet. Crowdsourcing is highly related to a few concepts that may be used to render similar concepts, including open innovation, co-creation, collective intelligence, user innovation, and open source. These are briefly described below.

2.2.1. Open innovation

The concept of open innovation is a paradigm which assumes that companies can and should use external ideas, in addition to internal ones, to facilitate innovations, share risks, and improve productivity and competitiveness [19,20]. There are several methods for importing external ideas, most notably: using consultants, employing focus groups, conducting joint design sessions with suppliers, and using other collaboration methods that were in use for decades to facilitate open innovation. Lately, however, several new methods and tools have been developed, notably: co-creation, user innovation [64], collective intelligence and crowdsourcing. A comprehensive coverage and typology can be seen at Sloane [62] and Loren [44].

2.2.2. Co-creation

Co-creation describes a joint effort of producers and consumers aiming to developing new products and services [51,71]. Co-creation may be initiated by producer firms or by consumers themselves. Co-creation can be viewed as a facilitator of open innovation. Co-creation is about working collaboratively with a group of people with specialized skills or talents to come out with great ideas. It differs from crowdsourcing in that crowdsourcing is about outsourcing projects or tasks to the public in order to collect a lot of ideas from the public, and usually involves choosing one idea to be implemented and awarded a prize. Co-creation differs from crowdsourcing by the depth and richness of the relationship between the producers and consumers.

2.2.3. Collective intelligence

Collective intelligence deals mainly with research issues related to innovation (actively conducted at the MIT Center for Collective Intelligence), specifically, how the wisdom of the crowd can increase innovations [63]. The MIT research investigates how people and computers can work together to be more innovative than any individual, group, or computer can be alone (see [45]). One of the tools that harness the collective intelligence of people is computer-based crowdsourcing. Collective intelligence is considered a common type of crowdsourcing [30].

2.2.4. User innovation

User innovation deals with individual users (or consumer users) innovating to make products and services they want without manufacturer (or producer) assistance [65]. Crowdsourcing differs from user innovation since crowdsourcing is firm-driven and not restricted to innovation issues, and allows any individual to get involved in the process [57].

2.2.5. Open source

Howe’s [32] definition of crowdsourcing is that it is an application of the open source principles. The philosophy underlying open source software (OSS) is to allow users to freely access, use, modify and redistribute software products and their source code under a public license [46]. The landscape of crowdsourcing is narrower than that of OSS [57].
3. Crowdsourcing and decision making

Although there are many potential applications of crowdsourcing, a major one is the support of the managerial decision making process [18,31]. A complicated problem that is difficult for a decision maker may be solved by a crowd. Crowds can generate a large number of ideas for solving a problem. Inappropriate use of crowdsourcing could also generate bad results. For example, a client firm choosing and implementing a work product that violates intellectual property (IP) rights might end up facing an injunction and/or a claim for damages. Therefore, it is valuable to investigate how crowdsourcing can be used properly to benefit organizations, with a minimal risk. In this section, we shall examine what roles a crowd may play in different stages of decision making, and the process for crowdsourcing in decision making.

3.1. Role of crowd in decision making

Crowds can provide ideas collaboratively or in a competitive mode. However, the crowd’s role may differ at different stages of the decision making process. We may use a crowd to provide information about a complex problem or use a crowd to help us decide whether a design is useful. In order to portray different needs in the decision process, we shall adopt Herbert Simon’s decision process model to outline the potential roles of a crowd. Simon’s model includes three major phases before implementation: intelligence (information gathering and sharing for the purpose of problem solving or opportunity exploitation, problem identification, and the determination of the problem’s importance), design (generating ideas and alternative solutions), and choice (evaluating the generated alternatives and then recommending or selecting the best course of action).

Crowdsourcing can provide different types of support to the managerial decision making process. Most of the applications are in the design phase (idea generation and co-creation) and in the choice phase (voting). In some cases, support can be provided in the other phases of decision making. Fig. 1 shows examples of roles that a crowd may play in different decision phases. These will be elaborated below.

3.1.1. The intelligence phase

In the intelligence phase, it is necessary to gather and/or share information about the nature of the problem or the opportunity to be investigated. This may be a difficult effort, so the problem owner may decide to use the help of the crowd.

Here are few examples of the crowds’ potential role in the intelligence phase:

- **Search and discovery.** Crowds can be used by companies for search and discovery (e.g., finding problems and/or the causes of problems). For examples, see Sherman [61].
- **Opinions.** Several governments use crowdsourcing to solicit opinions from citizens regarding potential improvements in government operations. Companies use customers to find out what is wrong with their existing products and solicit opinions about new products.
- **Predictions.** The crowd can be used to make predictions.
- **Knowledge accumulation.** Crowds are used in compiling and discovering (e.g., see a problem-focused crowdsourcing typology [18]) knowledge.

3.1.2. The design phase

Here, the crowd can be used for generating ideas and alternative solutions, and facilitating creativity and innovation as well as partnering in co-creation. The objective is to tap the power of the collective intelligence of the crowd to increase innovation [11,45]. Idea generation is done mainly in the following modes:

- Soliciting ideas from employees (in-house mode). This is basically an automation of the traditional “suggestion box.” An example is IBM’s InnovationJam [8]. Here, a large company leveraged its company-wide intelligence which is scattered worldwide.
- Soliciting ideas from customers or other outsiders. This can be done either in-house or by using an intermediary to collect ideas. Notable examples are MyStarbucksIdea, Nokia’s IdeasProject, Dell’s IdeaStorm, Lego Groups Lugnet, and SAP’s SAPIens (see details at [42]). Procter and Gamble (P&G), for example, uses Innocentive.com (an intermediary) to post problems to be solved. In addition, P&G uses NineSigma for crowdsourcing. Goldcorp challenged experts to identify where to dig for gold. The feedback helped the company to find substantial amounts of gold.
- Idea generation models. Two basic models of idea generation exist: cooperative (or collaborative) and competitive. Cooperative models can appear in several versions. Cooperation is considered useful when dealing with cumulative knowledge [13]. Competitive models are usually conducted by companies to find solutions to a problem (e.g., the BP Oil leak) or to improve performance (e.g., Netflix’s movie recommendation competition). A prize is offered to the winner. Another example is SAPIens [3]. In this case, the winner (there may be one or more) takes all. The competitive mode is popular in the case of co-creation.

Note that several companies use crowdsourcing for physical design purposes (the co-creator model). For example, Made.com and Furniturev.com solicit customers’ votes on proposed new products before they manufacture them. Threadless is a well-known community for designing T-shirts (see [41]). This company uses the crowd to design alternative products and then solicits the crowd’s opinion regarding the generated designs (evaluation of alternatives and then a choice of one). Polyvore.com is an example of a company that shares designs.
among community members. Xiaomi.com took advantage of new smartphone features solicited from their fan website to become a major player in China in three years, selling more than 30 million smartphones in 2013.

3.1.3. Choice

Here, the crowd may be involved in evaluating ideas (or performance) by analyzing the alternatives created in the design stage or identify crowd’s preference to support decision makers. Companies use consumers, for example, to provide feedback on proposed solutions to existing problems or on new designs (e.g., Threadless). Finally, the crowd can vote on proposed ideas to select the best one. The crowd may provide qualitative feedback as well. Several vendors, including Facebook and LinkedIn, provide voting mechanisms.

3.2. The crowdsourcing process for decision support

Most crowdsourcing systems share a similar process. Several researchers describe this process and its entities (or building blocks) in detail, but they may have named them differently (e.g., [17,21,31,45]).

Fig. 2 illustrates a typical crowdsourcing process. Starting from the left, a decision maker has a problem or an opportunity to be exploited. Then, the decision maker may decide to use crowdsourcing to deal with the situation. To do this, the decision maker selects a task (or tasks) to be crowdsourced (rather than to be done in-house or outsourced to institutions). A related activity here is to select the crowd and decide whether to manage the project in-house or outsource the administration to an intermediary.

The task is then broadcasted to the crowd, usually in an open call to all. Next, the members of the crowd work on the task(s). In the case of decision support, they generate alternative courses of action (idea generation). When the work is completed, the workers submit the results to the problem owner for evaluation. The evaluation is part of the process and it can be done by experts, by the crowd itself, by another crowd, or by management. A choice of a solution is done at the end of the evaluation.

Note that the process includes components (marked by rectangles) and activities (designated by ovals). These components are the basis for an organized framework that we propose next.

4. A framework for crowdsourcing support to decision making

Crowdsourcing is a multi-topic and multidisciplinary field. The number of publications has grown very rapidly, especially since 2012. Therefore, the opportunities for research are increasing and proper organization of existing research is helpful. In this section, we present a framework to help organize research in the area. The framework, which is built conceptually similar to the one used by Aral et al. [6], divides key elements related to crowdsourcing into four basic components: The task, the crowd, the process, and the evaluation (top of the matrix in Table 1).

4.0.1. The Task

Organizations deploy crowdsourcing when they have a problem they need to solve, when they want to exploit opportunities, or when they need a large amount of inexpensive labor to perform small tasks (microtasks) that they cannot or do not want to do in-house [58]. For example, Netflix outsourced the task of improving their movie recommendation system to the public via a team competition and offered a $1 million prize for it. The problem (or opportunity) is frequently related to the goal(s) of the outsourcer. These goals need to be defined clearly and communicated to those who will work on the specific task (the crowdworkers). From the problem statement (or definition), management will derive the task(s) to be outsourced to the crowd.

4.1. The crowd

The crowd refers to those workers to whom the work is outsourced. This entity may include different populations (non-experts, experts, informal members, customers, business partners, etc.). The size, composition, uniformity, and level of expertise of the participants describe the crowd.

4.2. The process

The process used in crowdsourcing depends on the type of supportive technology, the nature of the task, the use of an intermediary, and much more. A typical process can involve idea generation, co-creation of products, writing content (e.g., for Wikipedia), providing advice, or rendering feedback. The process can be collaborative or competitive. The process involves the flow of information, interactions and control, and collaboration.

4.3. The evaluation

The last entity is the evaluation of the submitted proposal of the crowd. At the completion of the work, the crowd members submit alternative solutions, or other output, that need to be evaluated. Here, there may be a need to combine the output of individuals, and to judge the quality of the work done in light of the stated goals. There are several.
methods of evaluation and several options for determining the evaluators.

Furthermore, each component may involve three different dimensions: managerial, behavioral, and technological.

1. **Managerial dimension**: Managerial concerns refer to organizational considerations when crowdsourcing is to be used, such as which task is suitable for crowdsourcing, what kind of crowd needs to be recruited, what kind of crowdsourcing process is more effective, and how to evaluate the process and outcome of crowdsourcing.

2. **Behavioral dimension**: Behavioral concerns refer to considerations related to the individuals involved in crowdsourcing, such as the impact of crowdsourcing on employees, how can the crowd be motivated, and so on.

3. **Technological dimension**: Technological concerns refer to technical issues related to the information systems/platforms used for supporting the crowdsourcing process, such as what functions are important for a crowdsourcing platform, how to design useful crowdsourcing models, how to improve system functionality for more effective communication in crowdsourcing.

Table 1 shows a matrix that illustrates the relationship between crowdsourcing entities and levels of concern. Examples illustrating research issues associated with each cell in the matrix are provided in Section 5.

### 5. Representative issues in the framework

To support the research framework, we conducted a literature search using the keyword of crowdsourcing to find 46 relevant research papers. With the organizing framework, we can classify previous studies by their research issues, main focus and respective categories, as shown in Appendix 1. A brief description of these representative issues is provided below.

#### 5.1. The task component

Three major dimensions are involved in the task component: managerial, behavioral, and technological. They are elaborated below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Task</th>
<th>Crowd</th>
<th>Process</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managerial</td>
<td>&gt; Task suitability</td>
<td>&gt; Incentive mechanisms</td>
<td>&gt; Crowdsourcing mechanism</td>
<td>&gt; Evaluation metrics</td>
</tr>
<tr>
<td></td>
<td>&gt; Task feasibility</td>
<td>&gt; Crowd selection</td>
<td>&gt; Feedback on the crowdsourcing process</td>
<td>&gt; Quality measurement</td>
</tr>
<tr>
<td></td>
<td>&gt; Task presentation</td>
<td>&gt; Determination of proper crowd size</td>
<td>&gt; Accessibility of peer contributions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Key capabilities involved</td>
<td>&gt; Diversity of the crowd</td>
<td>&gt; Legal issues</td>
<td></td>
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<tr>
<td></td>
<td>&gt; Task diversity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; Task complexity</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>&gt; Task decomposition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral</td>
<td>&gt; Impact of crowdsourcing on employees</td>
<td>&gt; Crowd's task selection behavior</td>
<td>&gt; Grouthink</td>
<td>&gt; User participation in evaluation</td>
</tr>
<tr>
<td></td>
<td>&gt; Employees' attitudes toward crowdsourcing</td>
<td>&gt; Crowd motives</td>
<td>&gt; Human biases</td>
<td>&gt; User attitude toward rating scale</td>
</tr>
<tr>
<td></td>
<td>&gt; Impact of task features on participants' outputs</td>
<td>&gt; Trust</td>
<td>&gt; Cheating in crowdsourcing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; Crowd's attitude toward participation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>&gt; Participation intention and behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology and Systems</td>
<td>&gt; Platform selection</td>
<td>&gt; Use of collaboration tools</td>
<td>&gt; Process monitoring</td>
<td>&gt; Outcome evaluation method</td>
</tr>
<tr>
<td></td>
<td>&gt; System functionalities</td>
<td>&gt; Participants' reaction to system functions</td>
<td>&gt; System architecture design</td>
<td>&gt; Use of idea evaluation tools</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; Collecting process data</td>
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<td></td>
<td></td>
<td></td>
<td>&gt; Use of social network</td>
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<td></td>
<td></td>
<td></td>
<td>&gt; Use of collaboration tools</td>
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<td>&gt; Use of artificial intelligence</td>
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<td></td>
<td></td>
<td></td>
<td>&gt; Platform usage profile</td>
<td></td>
</tr>
</tbody>
</table>

#### 5.2. Managerial dimension

Organizations may have plenty of managerial concerns when they choose crowdsourcing for a task, including how to select, design and manage the task to be crowd-sourced in order to achieve the goal. Three major issues under study in existing literature are task features, task design, and task selection. For example, Zheng et al. [70] investigated the role of task variety and task complexity in crowdsourcing. Several studies have examined issues related to task design for crowdsourcing, such as task decomposition [36], task presentation [57, 59], and key capabilities involved in crowdsourcing [48]. Task selection issues include task suitability [58] and task feasibility [1].

Another key issue that has been investigated broadly is the kinds of tasks that can better benefit from crowdsourcing (i.e., task suitability). For example, Schenk and Guitard [58] identified three types of tasks that are suitable for crowdsourcing: (1) simple (routine) tasks for which firms can benefit from the low-cost realization of tasks on a large scale, (2) complex tasks for which firms lack either skills or satisfactory in-house solutions, and (3) creative tasks in which creativity and uniqueness have a value. This provides a set of basic guidelines for choosing crowdsourcing tasks.

#### 5.3. Behavioral dimension

Applying crowdsourcing to problem solving is not without resistance. The behavioral dimension covers issues related to the impact of crowdsourcing on organizational personnel. Two major issues are (1) the impact of crowdsourcing on employees [37], and (2) employees’ attitudes toward crowdsourcing [20].

The reason that employee behavior is important is that crowdsourcing can be a double-edged sword. One the one hand, a firm can attract creative talents outside the organization for less than the minimum wage. On the other hand, the capable crowd may show an opportunity for the organization to replace current employees. Employees of the crowdsourcing organization may worry about job security [37]. Another issue in this dimension is how task features may affect participants’ outputs [47]. In this research, they found that task autonomy and meaningfulness positively impact perceived effort and performance, while perceived use of skills has a positive impact on perceived effort and a negative impact on perceived performance.
5.4. Technology dimension

Crowdsourcing cannot be done effectively without a proper technological platform. Therefore, platform selection [14] and system functionalities [21] are two major issues that have been investigated extensively. The first issue is about what kind of platforms is useful for crowdsourcing and whether the platform should be developed in-house for better control and security, or using an existing third-party solution is acceptable. The second issue is identifying proper system functionality necessary for handling different tasks. For example, Boudreau and Lakhan [14] suggested that, if a client firm wants to crowdsource a design task or creative project, a contest-oriented platform should be selected. Proper matching between platform functions and task types can enhance the performance of crowdsourcing.

5.5. The crowd component

The crowd is a key component that directly determines the eventual outcome of crowdsourcing. The same three major research dimensions are involved: managerial, behavioral and technological.

5.6. Managerial dimension

Crowdsourcing cannot be successful without the support of a high-quality crowd. Hence, the first line of research is about how to recruit, manage and motivate the crowd. Several studies have examined issues related to crowd composition, such as determination of proper crowd size [12, 25] and diversity of the crowd [15, 16, 54]. Crowd recruitment is another important management issue. For example, Geiger et al. [27] investigated how to select a proper crowd and identified two types of crowd selection mechanisms: qualification-based and context-specific. The qualification-based mechanism requires that the contributors demonstrate certain knowledge or skills before they are allowed to make regular contributions. The context-specific mechanism selects the crowd based on the attributes of the decision context. For example, a company may choose college students if the task is related to higher education.

Another key challenge in managing the crowd is how to design an incentive mechanism that helps attract high quality solutions. For example, using data from Threadless.com, Huang et al. [34] found that additional incentives associated with the reward for the winners could result in higher quality solutions. If an organization only provides incentives for participating in the contest, however, increasing competition resulting from the incentive may lower the quality of the solution.

5.7. Behavioral dimension

The success of a crowdsourcing depends on mass participation. Hence, it is of great importance to explore contributors’ perceptions, motivations and behavior toward crowdsourcing. A key issue that has been investigated extensively is the crowd’s motives to participate in crowdsourcing [5, 15, 39, 69, 70]. For example, Leimeister et al. [42] investigated contributors’ motivation to participate in an IT-based idea competition for enterprise resource planning software. They found that a diverse set of factors may motivate the crowd to participate, including learning, direct compensation, self-marketing and social motives.

Several studies have examined issues related to the crowd’s beliefs and attitudes, such as trust [36] and the crowd’s attitude toward participation [7]. Sample research issues include crowd’s task selection behavior [66] and participation intention and behavior [70]. For example, Yang et al. [66] examined user behavior on one of the biggest Witkey websites in China, Taskcn.com. They found that users tended to choose tasks with fewer participating opponents to increase their winning probability. They would also choose tasks with higher expected rewards.

5.8. Technology dimension

Technological tools or services can be used to enhance the crowd’s productivity in crowdsourcing. Two major issues in this dimension are (1) use of collaboration tools [5, 40], and (2) participants’ reaction to system functions [35].

The first issue is related to whether the use of collaboration tools can enhance the quality of crowd’s output. For example, Kittur et al. [40] indicated that the perception of poor crowd work quality was caused, at least partly, by unclear instructions and insufficient feedback, and that contributors need more guidance to better understand what is expected. Crowdsourcing platforms can provide a wider array of communication channels between the client organization and contributors to support synchronous collaboration and real-time crowd work.

The second issue is how crowd’s behavior may be affected by system functions (e.g., user interfaces). For example, Ipeirotis [35] analyzed the waiting time for the posted tasks on Mturk and found that contributors are limited by the current user interface and complete tasks. They could only pick the tasks available through one of the existing sorting criteria. Hence, improving system functionality may be able to enhance the crowdsourcing quality.

5.9. The Process component

The third key entity in crowdsourcing is the process, which also includes three major aspects: managerial, behavioral and technological.

5.10. Managerial dimension

There are plenty of managerial concerns for the crowdsourcing process. Three major issues that have been studied are process governance, process design, and legal issues. For example, Dow et al. [23] investigated feedback in the crowdsourcing process, and Geiger et al. [27] discussed the accessibility of peer contributions in crowdsourcing. Several studies have examined issues related to process design for crowdsourcing, such as infrastructure [2] and crowdsourcing mechanisms [13, 45, 49, 58]. Legal issues include intellectual property [11, 43] and privacy protection [27].

Other key issues that have been investigated extensively are the determination of the approach (e.g., competitive vs. collaborative) that is more suitable for the crowdsourcing task, and the impact of the approach (i.e., crowdsourcing mechanism). For example, Blohm et al. [9] indicated that user collaboration enhances idea quality and that inducing user collaboration is a viable design element for making idea competitions more effective.

5.11. Behavioral dimension

Designing and managing the crowdsourcing process needs to take into account the crowd’s improper behavior in the process. Two major issues that have been investigated are (1) groupthink [54] and (2) cheating in crowdsourcing [24, 67].

The crowd’s improper behavior in the process is an issue because crowdsourcing tasks can be undermined if a significant share of contributors are primarily interested in maximizing their financial gains by producing generic answers rather than actually working on the task [24]. Eichhoff and de Vries [24] indicated that implicit crowd filtering through task design is a superior means to control cheating. They concluded that cheaters are less frequently encountered in novel tasks that involve creativity and abstract thinking. Another issue in this dimension is human bias. In Bonabeau [11], they provided a list of human biases that could negatively affect an idea generation task, such as social interference (influence by others), and suggested that collective intelligence can help mitigate the effects of human biases.
5.12. Technology dimension

Information technologies and tools can be used to improve the idea generation process. Three major issues that have been studied are supporting mechanisms, system functions, and tool usage. Supporting mechanisms are process-related functions such as facilitating collaboration among contributors, which can be done by using real-time visualizations of completed tasks [22] and collecting process data from other participants to help contributors refine their ideas [42].

Another technology issue is system functionality useful for supporting the process of crowdsourcing, which includes system architecture design [28] and platform usage profiling [35]. Several studies have examined issues related to the use of tools for crowdsourcing, such as the use of collaboration tools [9,60], social networks [5] and artificial intelligence [40]. For example, Blohm et al. [9] suggested implanting collaboration tools in an idea competition as contributors, especially for those contributions who are intrinsically motivated, can be activated through means fostering and guiding social interaction.

5.13. The evaluation component

The large number of ideas generated from the crowdsourcing process needs to be evaluated carefully to obtain useful ones. Three dimensions are involved in the evaluation component: managerial, behavioral and technological.

5.14. Managerial dimension

Management of idea evaluation includes three major issues: selection of evaluators, quality measurement, and evaluation metrics [11]. The first issue is related to selecting proper experts to evaluate the outcome quality from the crowdsourcing process. Riedl et al. [53] suggested that, for innovation management, the crowdsourcing organization can organize a small team of interdisciplinary experts to evaluate new ideas. The second issue concerns the actual criteria for evaluating ideas. For example, Blohm et al. [10] proposed to use four distinct dimensions to measure idea quality, i.e., novelty, feasibility, relevance and elaboration. The third issue focuses on developing evaluation metrics for various types of crowdsourcing task. For instance, Bonabeau [11] identified several evaluation metrics and suggested that solution quality and output consistency are key metrics for R&D innovation.

5.15. Behavioral dimension

The crowd’s role and its response to the outcome evaluation present another important dimension of research, because they are useful for selecting proper evaluation mechanisms. User participation in the evaluation [50,55] and the user’s attitude toward the rating scale [53] are two major issues that have been investigated extensively. User participation is one way to do the evaluation. For example, Roy et al. [55] suggested that a faster, more reliable but costlier alternative for outcome evaluation is to explicitly designate some of the current contributors as the evaluators of submitted tasks. The second issue concerns the effect of rating scales on the contributors’ attitudes. For example, using system-captured experiment data, perceptually anchored questionnaire data, and an independent expert evaluation of idea quality, Riedl et al. [53] found that the multi-criteria rating scale (a multidimensional measure of quality, such as novelty and feasibility) is perceived more favorably than the single-criterion scale (aggregated measure of idea quality) in the co-creation context. Thus, designing rating (evaluating) scales is critical because it influences both rating outcomes and contributors’ attitudes and thus their intention to participate in crowdsourcing.

5.16. Technology dimension

To support the effective evaluation, appropriate development and use of technology is essential. This includes outcome evaluation methods [10,55] and the use of idea evaluation tools [56,67]. With regard to evaluation methods, Blohm et al. [10] proposed rating scales and prediction markets as two major evaluating methods for collective idea evaluation. They indicated that multi-criteria rating scales outperformed prediction markets in terms of evaluation accuracy and evaluation satisfaction. Roy et al. [55] proposed a hybrid evaluation method to perform task evaluation by combining a system’s acquired intelligence augmented with explicit human expertise. Yuen et al. [67] suggested that the crowdsourcing model embedded into the crowdsourcing platform’s control and evaluation mechanisms, such as quality control procedures (e.g., peer or specialist review, commenting systems) and competition schemes (e.g., voting, rating or bidding), are useful for enhancing crowdsourcing.

6. Conclusion and future research

Crowdsourcing is increasingly used in business decision making. Research in this area is growing rapidly to open research opportunities in the decision support area. A substantial amount of previous research has been published. The main purposes of this article are to identify the key components and their dimensions, and to propose an organizing framework to classify prior research and identify potential areas of interest for future research.

In the framework, we identified four components, each with three associated dimensions, to put together a framework with 12 cells. To the best of our knowledge, existing taxonomies or frameworks for crowdsourcing are not as extensive as ours and, thus, limit the identification and discussion of crowdsourcing issues. The framework serves as an initial roadmap to draw a complete picture of crowdsourcing activities and research issues.

The contribution of this work is twofold. From the operational perspective, it provides deeper insight into the kinds of things to which crowdsourcing organizations should pay attention in order to ensure the quality and success of the crowdsourced task. For instance, our framework shows that crowdsourcing success is restricted to neither task design nor incentive design alone. Instead, a multi-criteria assessment is necessary. From the academic perspective, this paper has proposed a synthetic and analytical view of the crowdsourcing research issues. While many existing works have provided insight into specific issues, we argue that a synthesis of various practices, along with some clear components and dimensions, is likely to be useful for further research in this area.

There is plenty of room for future research. Below are a few sample topics organized by our framework. In the task component, managerial topics may include (1) how to analyze fit and viability between tasks and crowdsourcing, (2) how to identify improper use of crowdsourcing, and (3) the development of justification models for different categories of crowdsourcing. Behavioral topics include the examination of the impact of crowdsourcing on employees’ job stress or well-being. Technological topics may include the impact of task-technology fit on crowdsourcing utilization and performance.

In the crowd component, managerial issues include (1) the circumstances under which diversity in the crowd is better than homogeneity, (2) when it is advisable to use volunteers, and how to compensate them, (3) whether financial incentives are more important than hedonic or social incentives in driving participant behavior, and (4) defining the relationships between the crowd and the problem owners. Behavioral issues include (1) social-technological mechanisms to motivate individuals to participate in crowdsourcing, (2) mechanisms to create trust in crowdsourcing, (3) whether the effect of motivations varies for different cultures,
and (4) how participants select specific tasks. Technological issues include (1) what tools can be used to monitor and collect data, and (2) how to properly develop infrastructure and select software for better crowd support.

In the process component, managerial issues include when the use of anonymity and when creating small subgroups is beneficial. Behavioral issues may include (1) how groupthink and other decision biases may be reduced in the crowdsourcing process, and (2) how to foster shared culture and value in the crowdsourcing process. Technological issues include how using technology to support process monitoring and other mechanisms may affect the resulting quality.

Regarding the evaluation component, managerial issues include how to assess various quality measures for different crowdsourcing tasks. Behavioral issues include how to evaluate the impact of user participation in the evaluation of the quality of the outcome. Technological issues include the development of new outcome evaluation methods and how these methods impact crowdsourcing efficiency, crowd behavior, and satisfaction.

The issues identified above are definitely not exclusive. The proposed framework provides a useful conceptual map for organizing existing research and developing new research issues in the future.

Appendix 1. Classification of Crowdsourcing Research

<table>
<thead>
<tr>
<th>Reference</th>
<th>Research Issue</th>
<th>Main Focus</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afuah and Tucci [1]</td>
<td>Factors affecting possibility of crowdsourcing</td>
<td>Task feasibility</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Schenk and Guitard [58]</td>
<td>Characterizing crowdsourcing</td>
<td>Task feasibility</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Schulze et al. [59]</td>
<td>Properties of crowdsourcing tasks</td>
<td>Task presentation</td>
<td>Process-Managerial</td>
</tr>
<tr>
<td>Nevo et al. [48]</td>
<td>Successful utilization of crowdsourcing</td>
<td>Key capabilities involved in crowdsourcing</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Zheng et al. [70]</td>
<td>Effect of task design and motivation on participation intention</td>
<td>Task variety</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Jain [36]</td>
<td>Governance mechanisms for crowdsourcing initiatives</td>
<td>Trust</td>
<td>Task-Behavioral</td>
</tr>
<tr>
<td>Jayanti [37]</td>
<td>Challenges of crowdsourcing for human resource development practitioners</td>
<td>Impact of crowdsourcing on employees</td>
<td>Task-Behavioral</td>
</tr>
<tr>
<td>Mousawai and Koufaris [47]</td>
<td>Effect of task design on participants’ motivation and outputs</td>
<td>Use of artificial intelligence</td>
<td>Task-Technology</td>
</tr>
<tr>
<td>Kittur et al. [40]</td>
<td>Challenges of crowdsourcing</td>
<td>Use of idea evaluation tools</td>
<td>Crowd-Technology</td>
</tr>
<tr>
<td>Doan et al. [21]</td>
<td>Crowdsourcing systems on the Web</td>
<td>System functionalities</td>
<td>Task-Technology</td>
</tr>
<tr>
<td>Boudreau and Lakhani [14]</td>
<td>When and how to use crowdsourcing</td>
<td>Platform selection</td>
<td>Task-Technology</td>
</tr>
<tr>
<td>Huang et al. [34]</td>
<td>Impact of incentive structure on solution quality</td>
<td>Crowdsourcing mechanism</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Ericson et al. [25]</td>
<td>How to match crowdsourcing need with crowd characteristics</td>
<td>Incentive mechanisms</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Brabham [15]</td>
<td>Composition of the crowd and motivations for participation</td>
<td>Determination of proper crowd size</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Brabham [16]</td>
<td>Idea diversity</td>
<td>Diversity of the crowd</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Boudreau et al. [12]</td>
<td>Effect of competitor size and problem uncertainty</td>
<td>Crowds’ motives</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Geiger et al. [27]</td>
<td>Managing the crowd</td>
<td>Determination of proper crowd size</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Rosen [54]</td>
<td>Factors affecting decision making in crowdsourcing</td>
<td>Use of idea evaluation tools</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Yang et al. [60]</td>
<td>Strategic user behavior in crowdsourcing</td>
<td>Crowd’s task selection behavior</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Kaufmann and Schulze [39]</td>
<td>Motivation in crowdsourcing</td>
<td>Crowd’s motives</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Zhao and Zhu [69]</td>
<td>Motivation in crowdsourcing contest</td>
<td>Crowd’s motives</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Bakici [7]</td>
<td>Motives for participation in open innovation</td>
<td>Crowd’s attitude toward participation</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Antikainen et al. [5]</td>
<td>Motivating and supporting collaboration</td>
<td>Crowd’s motives</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Leimeister et al. [42]</td>
<td>Motives, incentives and activation</td>
<td>Use of collaboration tools</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Ipertosis [35]</td>
<td>Dynamics of the crowdsourcing marketplace</td>
<td>Use of social network</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Yuen et al. [67]</td>
<td>Categorization of crowdsourcing systems</td>
<td>Use of idea evaluation tools</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Pisano and Verganti [49]</td>
<td>Collaboration options, ways and modes</td>
<td>Evaluating participants’ reaction to system functions</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Malone et al. [45]</td>
<td>Identifying building blocks of collective intelligence</td>
<td>Crowdsourcing mechanism</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Dow et al. [23]</td>
<td>Effect of task-specific feedback</td>
<td>Feedback in the crowdsourcing process</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Lieberman et al. [43]</td>
<td>Risk of crowdsourcing</td>
<td>Legal issues (intellectual property)</td>
<td>Task-Managerial</td>
</tr>
<tr>
<td>Boudreau and Lakhani [13]</td>
<td>Organization of outside innovation</td>
<td>Crowdsourcing mechanism</td>
<td>Task-Managerial</td>
</tr>
</tbody>
</table>

(continued on next page)


