Abstract

Improving decision-making requires examining and applying effective techniques. This paper contrasts three decision-making approaches using primary election results as a baseline. Election voting, multi-criteria decision analysis (MCDA), and collaborative decision-making (CDM) capitalizing on collective intelligence are compared to evaluate the utility of the approach along with the benefits and issues with each. The CDM approach was significantly more effective at improving the decision-making process by providing a rich dataset for the analysis of alternatives. An open, collective intelligence process demonstrates the potential for eliciting both evaluation criteria and decision alternatives to increase the efficacy of the decision analysis and potential for identifying an optimal decision alternative.

1. Introduction

Decision-making is such a fundamental process, so integrated into our daily activities, that few people take the time to look critically at the effectiveness of their decision-making in the context of evaluating outcomes and improving the consistency of the decision process to enhance the reliability of decision outcomes. We take it for granted that we are capable decision-makers and that our decision-making ability is not a factor in the outcomes, or if it is, it is only the self-reinforcing belief that it is a major factor in positive outcomes, and a relative non-factor in negative outcomes. We consistently overestimate our abilities [1,10].

Peter Nutt highlights the problem in business decision-making as “managers can recall their success and failures, but seldom subject them to a systematic analysis” [9]. The result is that the strategies and tactics employed by decision-makers are oftentimes ineffective, or worse, that the effective strategies and tactics are not recognized and consistently employed. Two of every three decisions Nutt studied used tactics prone to failure. Nutt, after two decades of studying decisions in organizations, draws a sobering conclusion - “half of decisions made in organizations fail” [9].

A recent report from the management consulting firm McKinsey & Company confirms Nutt’s conclusions and highlights the ongoing challenge with strategic decision-making. In their 2009 survey of 2207 executives, McKinsey reported that 60% of executives admitted they made bad decisions as often as good decisions, while 12% of the respondents acknowledged that their organizations made “good decisions” infrequently [5].

To counter the problem of ineffective decision-making and improve the overall effectiveness of decision-making, organizations are investing heavily in technology, specifically business intelligence tools and analytics. Advisory firm Gartner, Inc. conducted a survey of 2053 Chief Information Officers across 36 industries in 41 countries and determined that business intelligence and analytics were their top implementation priority [6]. These CIOs seem to be responding to a business imperative to supplement the decision-making process with technology.

As organizations grapple with the implementation of business intelligence tools, they must also consider the underlying decision processes and use technology to not only present the analysis of business data, but also employ methods that assist the decision-makers in the synthesis of decision alternatives. One well-researched approach that has produced a variety of methodologies is multi-criteria decision analysis. MCDA methodologies use a set of criteria to evaluate decision alternatives and produce an optimized solution [3]. MCDA evaluations can be done informally, as simply as considering a choice in the context of individual preferences, or more formally by developing extensive sets of well-defined criteria and performing the evaluation in a highly structured manner. MCDA is applicable to both structured and unstructured problems or decisions where it is desirable to consider multiple alternatives and perform a consistent evaluation.

We must not neglect the human in the decision improvement equation. An individual has the ability to
process information and reason with levels of abstraction that will, for the foreseeable future, elude even the most sophisticated information technology. More importantly, we must consider the implications of groups of people engaged in the decision-making process. The emergent property of people working together collaboratively, referred to as “collective intelligence,” has the potential to produce even more effective decisions. Thomas Malone, Director of the MIT Center for Collective Intelligence suggests “it is now possible to harness computer technology to facilitate “collective intelligence” - the synergistic and cumulative channeling of the vast human and technical resources now available over the internet” [8]. To enjoy the benefits of collective intelligence, he believes we need “a new kind of web-mediated discussion and decision-making forum” [8].

The focus of this paper is a comparison of three decision-making techniques using election results as a basis for evaluating the predictive effectiveness of a simple MCDA methodology and a collaborative decision-making methodology that is a combination of collective intelligence and MCDA. We will contrast the methodologies, identify the benefits of MCDA evaluations over polling, and explore the implications of a web-mediated decision-making forum and collaborative decision-making. From the perspective of business decision-making, we will demonstrate that the collaborative decision-making techniques discussed in this paper represent a more meaningful approach to evaluating decision alternatives.

2. Background on the “inqiri” collaborative decision-making solution

Developed by Cognitive Extension, Inc., “inqiri” is a web-based collaborative decision-making application that combines a MCDA methodology with an open collection process designed to elicit input from participants in a structured, quantifiable manner. The openness and structure of the process creates the necessary conditions to manifest the collective intelligence phenomenon.

Hosted in the cloud, inqiri is able to leverage the openness of the Internet to gather input from a virtually unlimited pool of potential participants. By channeling the participation into a structured process with quantifiable inputs, inqiri is able to aggregate the input of contributors and incorporate the data into the evaluation of the decision alternatives. By applying functional anonymity to the participant’s contribution, inqiri encourages candor and minimizes the biasing effect of group discussions or other, more overt forms of collaboration.

The inqiri solution utilizes the TOPSIS MCDA methodology as a basis for the analysis of decision alternatives.

2.1 The TOPSIS Methodology

Originally developed by Hwang and Yoon [7] in 1981, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) provides a well-researched and useful multi-criteria decision analysis methodology. By representing alternatives in relationship to the geometric distance to the positive ideal solution and negative ideal solution, TOPSIS allows the comparison of both the positive and negative dimensions of an evaluation. The optimum alternative is the one closest to the positive ideal and furthest from the negative ideal.

Another prominent feature of the TOPSIS methodology is the compensatory aggregation of criteria ratings, which produces a potential for trade-offs between criteria, where a negative value for one criterion can offset or counterbalance a positive value in another criterion. This avoids the strict hierarchical ranking of criteria in many of the most popular multi-criteria decision analysis methodologies, and their inability to establish equivalency between various evaluation criteria.

A TOPSIS analysis encompasses the following steps:

1. Suppose there are m options and n criteria. Given a matrix $X$ with each value $x_{ij}$ being a rating of option $i$ on criterion $j$, derive the normalized decision matrix $Y$ with terms $y_{ij}$ such that

$$y_{ij} = x_{ij} / \sqrt{\sum_{a=1}^{m} x_{aj}^2}$$

for $i = 1, ..., m, j = 1, ..., n$

2. Calculate the weighted normalized decision matrix. The weighted normalized value $v_{ij}$ is calculated as

$$v_{ij} = w_j y_{ij}$$

where $w_j$ is the weight of the $j$th attribute or criterion, and $\sum_{b=1}^{n} w_b = 1$.

3. Determine the positive ideal and negative ideal solution

$$A^+ = \{v_1^+, ..., v_n^+\} \text{ where } v_j^+ = \max_{1 \leq a \leq m} v_{aj}$$

$$A^- = \{v_1^-, ..., v_n^-\} \text{ where } v_j^- = \min_{1 \leq a \leq m} v_{aj}$$
2.2 The inqiri process

In its most simplified form, a decision involves two tasks, the generation of alternatives and their evaluation. [15] The process of participating in an inqiri (the term used to describe a decision under consideration in the inqiri application) is composed of four steps for each individual participant.

The inqiri process begins with an individual constructing an inqiri, which is simply a decision posed as a question that is best satisfied by evaluating multiple alternatives (i.e. not a yes/no question). Individual participants will then be presented with an opportunity to participate by either invitation, social media exposure, or searching the site for available inqiri.

**Step 1: Select criteria** – participants are asked to identify criteria that they believe will be useful in evaluating decision alternatives. They can search for existing, pre-defined criteria, or they can create their own, unique criteria. They are also presented with a list of possible criteria that is derived from other similar inqiri.

Inqiri aggregates all criteria selected or created by participants for presentation in the next step.

**Step 2: Rate criteria** – participants are presented with an aggregated list of criteria from all participants. They are asked to rate the relative importance of the presented criteria for the evaluation of decision alternatives.

(4) Calculate the Euclidean distance $d_i^+$ from each option $i$ to the positive ideal solution in criteria space.

$$d_i^+ = \left\{ \sum_{j=1}^{n} (v_{ij} - v_j^+)^2 \right\}^{\frac{1}{2}} \quad i = 1, \ldots, m$$

Similarly, calculate the distance $d_i^-$ to the negative ideal solution.

$$d_i^- = \left\{ \sum_{j=1}^{n} (v_{ij} - v_j^-)^2 \right\}^{\frac{1}{2}} \quad i = 1, \ldots, m$$

(5) Calculate a resulting score $R_i$ based on $d_i^+$ and $d_i^-$ for each option $i$.

$$R_i = d_i^- / (d_i^+ + d_i^-) \quad i = 1, \ldots, m$$

$R_i$ will always be a number between 0 and 1, i.e. $R_i \in [0,1]$.

(6) Produce a rank order list of options based on their $R$ scores. A higher score signifies a better option.

2.3 Manifesting collective intelligence

Inqiri is able to manifest a collective intelligence result by encouraging the diversity of the participants, isolating the individual contributions and ratings to avoid biasing or “group think,” and by providing a consistent process for participants to follow, allowing inputs to be analyzed effectively [13]. Additionally, the open nature of the criteria and option selection encourages knowledge elicitation. Individuals with unique perspectives can define a criterion or option, and increase the set of criteria or options under consideration by the group of participants. This elicitation effect increases the potential for the identification of optimally affect decision alternatives.

To further support the characterization of inqiri as a collective intelligence application, we turn to the collective intelligence genome framework developed by Thomas Malone at MIT [12]. This simple framework uses two pairs of related questions:

- Who is performing the task? Why are they doing it?
- What is being accomplished? How is it being done?
The genome model applied to inqiri yields the following results in Table 1.

Table 1. Collective Intelligence Genome

<table>
<thead>
<tr>
<th>What</th>
<th>How</th>
<th>Who</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create</td>
<td>Collection</td>
<td>Crowd</td>
<td>Intrinsic motivation</td>
</tr>
<tr>
<td>Decide</td>
<td>Averaging (TOPSIS)</td>
<td>Crowd</td>
<td>Intrinsic motivation</td>
</tr>
</tbody>
</table>

An inqiri can satisfy both hierarchical and crowd definitions, but for the purpose of this analysis, we will focus on the crowd genome. Members of the crowd, participating in an inqiri, are able to both create new criteria and options, meeting the requirements of the “create genome,” which calls for actors to generate something new. Members of the crowd also satisfy the “decide genome” by evaluating the proposed alternatives. The select criteria and select options portion of the inqiri process, where participants input is collected and aggregated, satisfies the collection genome for the create function. In the decide function, the TOPSIS methodology supplants the notion of “averaging” with a more sophisticated analysis of individual input. Finally, with regard to motivation, Malone acknowledges the limitations of the three types of motivation used by the genome analogy. In place of the money, love, and glory alternatives, we propose that motivations of participants are intrinsic in nature without further elaboration, as inqiri does not offer any external recognition or compensation normally associated with extrinsic motivation.

What defines a collective intelligence application remains rather amorphous. After reviewing over 250 examples of web-based collective intelligence applications, Malone admits that they exhibit a “wildly varying array of purposes and methods”[12] The Collective Intelligence Genome framework provides reasonable basis to evaluate the various functions and lends structure to the claim that inqiri is a collective intelligence application.

3. The Race for Reno Mayor

In February of 2014, a Nevada Supreme Court decision regarding the application of term limits in state law to the Reno mayor’s office eliminated two leading contenders and opened up the race to a primary field of 20 candidates. The candidates covered a broad spectrum of backgrounds and political experience.

Such a large slate of candidates proved to be unwieldy for political events like the initial debates, and necessitated a vetting process for the top candidates in subsequent debates. The local newspaper and public broadcasting station KNPB, hosts of the debates, developed an evaluation process for segmenting the candidates into multiple, smaller debate groupings.

On June 10th the primary election provided a more meaningful evaluation of the candidates in the form of election results. The primary election winnowed the candidates from 19 (one candidate withdrew, one candidate died from a drug overdose, but remained on the ballot), down to top two candidates, who will be on the November ballot.

Data from both the debate selection process and the primary election results provide two distinct rankings of the candidates with which a comparison can be made to the results from the inqiri solution. In the case of the primary election, we have a simple voting result. The debate selection process used a non-weighted, three (3) criteria decision evaluation (simple MCDA). The inqiri solution based the evaluation of the candidates on thirty (30) criteria.

4. Primary Election Voter Results

It may seem counter-intuitive, but the starting point for this analysis is the actual results from the June 10, 2014 primary election. These results serve as the baseline and comparison point for the remainder of this paper. We will only use the election results for top ten candidates and focus on these candidates for the analysis.

Table 2. Election Results [11]

<table>
<thead>
<tr>
<th>Election Results</th>
<th>Candidate</th>
<th>Votes</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hillary Schieve</td>
<td>6,629</td>
<td>26.21%</td>
</tr>
<tr>
<td></td>
<td>Raymond Pezonella</td>
<td>4,550</td>
<td>17.99%</td>
</tr>
<tr>
<td></td>
<td>Idora Silver</td>
<td>2,697</td>
<td>10.66%</td>
</tr>
<tr>
<td></td>
<td>Eddie Lorton</td>
<td>2,194</td>
<td>8.68%</td>
</tr>
<tr>
<td></td>
<td>Charles Reno</td>
<td>2,127</td>
<td>8.41%</td>
</tr>
<tr>
<td></td>
<td>Robert Avery</td>
<td>1,781</td>
<td>7.04%</td>
</tr>
<tr>
<td></td>
<td>Marsha Berkbigler</td>
<td>1,288</td>
<td>5.09%</td>
</tr>
<tr>
<td></td>
<td>Ken Stark</td>
<td>1,148</td>
<td>4.54%</td>
</tr>
<tr>
<td></td>
<td>Erik Holland</td>
<td>714</td>
<td>2.82%</td>
</tr>
<tr>
<td></td>
<td>DeLores Aiazzi</td>
<td>666</td>
<td>2.63%</td>
</tr>
</tbody>
</table>

*remaining 5.93% distributed among candidate 11 – 19.

4.1 Benefits of the election results

The primary benefit of the election results is that it provides a very good baseline for the analysis. The election results represent the official tabulation of the votes and it is a safe assumption that an election, conducted in a rigorous manner, avoids voter fraud and other inconsistencies.
The population participating in the election is significant at over 25,000 voters.

### 4.2 Issues with the election results

While voting and polling techniques are a time honored means of evaluating the “will of the people” in an election, the data is extremely one-dimensional. We simply have the tally of votes and the percentage of the total votes cast, but we have no other data describing the reasoning behind the result. Technically, we have a collective result, in this case from a population of over 25,000 people, but there is little insight to be gathered from the resulting data.

We also understand nothing about the participating population, other than that they are registered voters. Perhaps exit polling will provide some indication of the demographics of the voters participating in the election, but that is still a statistical extrapolation, rather than a direct measure of demographic data.

We acknowledge that in an election setting there are legitimate reasons for anonymity and this prevents more detailed analysis of voting results, however, it begs the question about the efficacy of voting as a methodology for making informed decisions, especially in a business environment.

As we will see later in the analysis, voting captures only a voter’s indication of positive preference (recognizing that some voter’s vote for the candidate they dislike the least). This one-dimensional indication of preference loses a significantly valuable dataset in the form of negative preference.

### 5. A simple MCDA ranking

With such a large slate of candidates, it was difficult for local media to manage a range of what might be considered “standard campaign coverage” and events. From profiling candidates to organizing the debates, it was difficult to coordinate effectively.

#### Table 3. Debate MCDA Results

<table>
<thead>
<tr>
<th>Election Rank</th>
<th>Candidate</th>
<th>Ballots (7,522)</th>
<th>Ballot Rank</th>
<th>Funds</th>
<th>Funds Rank</th>
<th>Social Media</th>
<th>Social Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Idora Silver</td>
<td>2,369</td>
<td>1</td>
<td>$106,721</td>
<td>3</td>
<td>4,091</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Marsha Berkbigler (TIE)</td>
<td>2,281</td>
<td>3</td>
<td>$64,680</td>
<td>7</td>
<td>4,990</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Hillary Schieve (TIE)</td>
<td>1,814</td>
<td>4</td>
<td>$100,503</td>
<td>4</td>
<td>3,600</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Robert Avery</td>
<td>2,341</td>
<td>2</td>
<td>$98,409</td>
<td>5</td>
<td>2,426</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Raymond Pezonella</td>
<td>1,528</td>
<td>5</td>
<td>$110,011</td>
<td>1</td>
<td>490</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>Ken Stark (TIE)</td>
<td>1,103</td>
<td>8</td>
<td>$70,385</td>
<td>6</td>
<td>1,878</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Eddie Lorton (TIE)</td>
<td>864</td>
<td>10</td>
<td>$109,785</td>
<td>2</td>
<td>2,737</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Charles Reno</td>
<td>1,146</td>
<td>7</td>
<td>$30,395</td>
<td>8</td>
<td>1,472</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>DeLorece Aiazzi</td>
<td>877</td>
<td>9</td>
<td>$20,257</td>
<td>9</td>
<td>916</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>Ian Pasalich</td>
<td>1,484</td>
<td>6</td>
<td>$2,800</td>
<td>10</td>
<td>478</td>
<td>10</td>
</tr>
</tbody>
</table>

To address this problem, the local newspaper and public broadcasting station, hosts of the debates, developed a simple MCDA process to vet candidates for the second round of debates. “The Reno Gazette-Journal and KNPB will host two televised debates for the 10 most-viable Reno mayor candidates, as determined by three equally weighted criteria.”[4] The three criteria included the following:

- Newspaper ballots for individuals interested in expressing support for a candidate;
- Second, the compiled campaign finance data for each candidate, considering total campaign contributions, as well as providing data on the top three contributors for each campaign;
- Third was the total number of social media followers on a candidate's campaign Facebook and Twitter pages.

The results of the debate MCDA provided the rank ordered list of candidates in Table 3.

#### 5.1 Benefits of the simple MCDA approach

Using multiple criteria to evaluate and rank the candidates provides the immediate benefit of additional context for the ranking results. With a MCDA, even a simple version, a contrast can be made between criteria and a rationale for the ranking can be interpreted. There is sufficient data to begin a variety of analyses, and it is possible to develop insights beyond the simple rank ordering of results.

Even with a simple MCDA, the applicability and utility in a business decision-making context becomes
clear. Not only does it produce a ranking list of alternatives, it provides information for further analysis, thus creating a better-informed decision-maker.

5.2 Issues with the simple MCDA approach

There are several issues with the simple MCDA approach developed by the newspaper and TV station for evaluating candidates. The most significant of which relates to integrity of the process for collecting ballots and some potential inflation of social media followers. It is unclear at this point, if the process for collecting ballots through the newspaper included protections to prevent fraud or other forms of manipulation. Could an individual cast multiple ballots, thus undermining the integrity of the ballot process? While we have reasonable assurance that the official primary election results were not subject to fraud, we cannot be similarly assured about the newspaper’s ballot process.

With the social media followers criterion, there was speculation that some candidates may have artificially inflated their social media followers by using paid services to garner new followers. It is an interesting criterion if one assumes that there is a correlation between social media followers and the candidate’s popularity, but it does not seem to be substantiated by the results. Several of the candidates with high social media followers did not translate into an equivalent ratio of votes in the election. Social media followers do not appear to have any meaningful correlation to a candidate’s viability.

The use of multiple criteria does provide more data for analysis, but the three selected criteria do not provide sufficient integrity or relevance to provide anything more than a simple ranked result. The criteria are independent and in evaluating the individual criterion ranking results, there are significant variations in the rankings. Only two candidates displayed reasonably consistent ranking across all three criteria.

The simple MCDA does not provide a high level of predictive value. None of the candidate’s rankings correlate between the debate ranking results and the primary election results. Five candidates rose in the election results, and five candidates fell in the election results.

6. Collaborative decision-making (CDM) results

The generation of a collaborative decision-making result relied on the inqiri application for both collection and analysis of the participant inputs. The framing of the inqiri was a single question, “Who should be the next Mayor of Reno?” with the detailed explanation as follows, “With a field of almost 20 candidates from a wide variety of backgrounds, we want to better understand what the people want in a candidate. With so many candidates running, who is the most qualified, the most popular and the most likely to win the election? On June 10th, the people will vote, narrowing this field to only two candidates. Help us determine who should be the next mayor of Reno.”

The solicitation of participants took the form of e-mail and social media outreach, requesting participation, and the result of coverage in the local newspaper. The Reno-Gazette Journal wrote an article outlining the inqiri on the Mayor’s race and published a URL to the site [2]. By the June 10 election, the inqiri had 86 individual participants.

6.1 Criteria aggregation results

Unlike the simple MCDA approach, the inqiri process allowed individual participants to select and define unique criteria that they felt were the necessary qualifications for mayor. Over the course of the collection period 30 separate criteria were introduced into the evaluation providing an opportunity to gather participants perspectives on how the candidates met criteria as diverse as “strategic vision” and “humor.”

One interesting result on the criteria was the introduction of two objectionable criteria: race and gender. Most would agree that race and gender are not relevant criteria for evaluating a candidate for office, however, in an open system, anything can happen, and one participant entered these two criteria. The collective intelligence of the participants responded with maximum effectiveness. Within a matter of days, both criteria received numerous severely negative relevance ratings and the collective was result relegated them both to the bottom of the criteria rank results. This single result confirms the wisdom of the crowd, the power of collective intelligence, and simultaneously restored our faith in humanity.

The top ten weighted criteria (and their descriptions) for evaluating candidates in the Mayor’s race, gathered and ranked through the collaborative decision-making process, are as follows:

1. Strategic Vision - A long-term view of what an organization or entity wants to be, concentrating on the future.
2. Ethics - The moral principles of an individual. A set of concepts and principles that guide us in determining what behavior helps or harms.
3. Management Ability - The act of coordinating the efforts of people to accomplish desired goals and objectives using available resources efficiently and effectively in all business and organizational activities.

4. Financial Management Expertise - The efficient and effective management of money in such a manner as to accomplish the objectives of an organization.

5. Temperament - An individual's character, disposition, and tendencies as revealed in his reactions.

6. Innovative - Always on the lookout for new ways to provide critical government services.

7. Bring People Together - Get the right people involved in solving problems and getting the work done.

8. Economic Development Experience - Track record of sustained, concerted actions of policy making or other efforts that promote the standard of living and economic health of a specific area.

9. Diplomacy - The art and practice of conducting negotiations between representatives of groups, states, or countries.

10. Persuasiveness - The power to induce the taking of a course of action or the embracing of a point of view by means of argument.

6.2 Collaborative decision-making results

The results from the inqiri application, unlike polls or surveys, are longitudinal. They evolve over time as more individuals participate and more criteria are added. For the purposes of this analysis, we will use two points in time, first the June 10 Election Day, and May 29 debate ranking results date.

The results in Table 4 and Table 5 include the delta between inqiri CDM results and both the election and the debate ranking for comparison.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Candidate</th>
<th>inqiri Rank</th>
<th>Delta Election</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hillary Schieve</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Raymond Pezonella</td>
<td>16</td>
<td>-14</td>
</tr>
<tr>
<td>3</td>
<td>Idora Silver</td>
<td>7</td>
<td>-4</td>
</tr>
<tr>
<td>4</td>
<td>Eddie Lorton</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Charles Reno</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Robert Avery</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Marsha Berkbigler</td>
<td>8</td>
<td>-1</td>
</tr>
<tr>
<td>8</td>
<td>Ken Stark</td>
<td>11</td>
<td>-3</td>
</tr>
<tr>
<td>9</td>
<td>Erik Holland</td>
<td>13</td>
<td>-4</td>
</tr>
</tbody>
</table>

6.3 Comparison of all results

Table 5 includes the election results, inqiri results from election day and the May 29 debate timeframe, and the debate ranking, and we are able to see the predictive accuracy (or lack thereof) of both the CDM and simple MCDA techniques.

6.4 Benefits of the CDM approach

It is immediately apparent that the strongest benefit of the CDM approach is the direct evaluation of candidates based on an expansive set of criteria. This allows the solicitation of individual perspective on the candidates in the context of specific qualifications. The collection of rating results on individual criteria opens up the potential for a variety of analyses, which is beyond the scope of this paper.

The longitudinal data can also provide unique insights as results change over time and as new evaluation criteria are presented. As demonstrated with the comparison of the results at the debate timeframe and election day. For example, Idora Silver ranked #2 at the debate timeframe, and ranked #1 in the debate results.

The aggregation of ratings in the CDM process, with TOPSIS as the basis for the analysis and ranking of results produced an accurate, predictive result, in the case of Hillary Schieve, the winner of the election.

6.5 Issues with the CDM approach

While the CDM approach produces a significantly more complex dataset, it is currently unable to collect and integrate non-participant contributed data into the analysis. Information such as campaign finance and other objective, quantifiable data could add value to the analysis. The capabilities of the inqiri application allow external data references for the consumption of the participants, but do not directly incorporate external datasets into the analysis. Work remains to be done on the anti-biasing aspects of the system. Currently, inqiri provides certain anti-biasing, anti-fraud detection capabilities, and these need to be enhanced to provide more sophisticated detection and mitigation.

Demographic analysis was not part of this analysis, as participants neglected to contribute sufficient demographic data to meaningfully analyze. Future enhancements to the inqiri application will prompt new users to provide demographic data and
facilitate improved demographic analysis of the respondents.

While the predictive potential of CDM is compelling, it is not, by design, a methodology for prediction. It is better suited to decisions under uncertainty, where the collective intelligence has the potential to identify optimal alternatives.

The mayor’s race represents a set of fixed options, and did not allow for alternative elicitation. The criteria elicitation demonstrated the efficacy of the crowd-sourcing of criteria, and the same potential exists for identifying novel alternatives in an more unbounded decision.

6.6 The Anomaly

On the surface, the ranking results for candidate Ray Pezonella seem to be badly misaligned with the other results, however further analysis yielding an interesting finding; that the inqiri CDM application is able to synthesize both positive and negative sentiment.

This was not simply a ranking anomaly, but it was the direct result of the collection of both positive and negative preference from participants. This is a capability in the inqiri CDM approach that cannot be duplicated or extrapolated from the election results or simple MCDA approach.

Figure 1 provides a breakdown of the top five candidates aggregate ratings on the top ten criteria. It is clear from the results that Candidate Pezonella received multiple negative ratings on highly valued criteria, including “strategic vision” and “bringing people together.”

Figure 2 indicates that this was not a simple case of bias or intentional manipulation. We analyzed the distance relationship between the top two candidates ratings (i.e. Schieve a +5 and Pezonella a -5 would be a strong bias, Schieve a +5 and Pezonella a +4 a weak bias). The results of the bias analysis confirm that the ratings were not unfavorably biased towards or against an individual candidate.

7. Discussion

The comparison of election results, a simple MCDA, and a collaborative decision-making solution using the Reno Mayor’s race as a uniform focus for analysis provides an opportunity to highlight the strengths and weaknesses of the respective approaches. Each of the approaches involved input from individuals, either voters or ballots, and in the case of the CDM approach, voluntary participants.

The results of the three approaches were highly variable. The CDM approach accurately reflected the winner of the election. However, both the simple MCDA and the CDM failed to have significant predictive value.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Candidate</th>
<th>inqiri Rank</th>
<th>Delta Election</th>
<th>inqiri Debate</th>
<th>Delta Debate</th>
<th>Debate Rank</th>
<th>Delta Debate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hillary Schieve</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Raymond Pezonella</td>
<td>16</td>
<td>-14</td>
<td>16</td>
<td>-11</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Idora Silver</td>
<td>7</td>
<td>-4</td>
<td>2</td>
<td>-1</td>
<td>1</td>
<td>-2</td>
</tr>
<tr>
<td>4</td>
<td>Eddie Lorton</td>
<td>3</td>
<td>1</td>
<td>14</td>
<td>-7</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Charles Reno</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Robert Avery</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>7</td>
<td>Marsha Berkbigler</td>
<td>8</td>
<td>-1</td>
<td>8</td>
<td>-6</td>
<td>2</td>
<td>-5</td>
</tr>
<tr>
<td>8</td>
<td>Ken Stark</td>
<td>11</td>
<td>-3</td>
<td>11</td>
<td>-5</td>
<td>6</td>
<td>-2</td>
</tr>
<tr>
<td>9</td>
<td>Erik Holland</td>
<td>13</td>
<td>-4</td>
<td>12</td>
<td>6</td>
<td>18</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>DeLores Aiazzi</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>-1</td>
</tr>
</tbody>
</table>

More importantly, the analytical value of the datasets derived from each approach strongly favors the CDM approach. Voting data was virtually one-dimensional, and the simple MCDA data brought together three independent sets of data, but did not provide a means to integrate the data into a useful analysis. The CDM approach was far superior in that it elicited and weighted 30 separate criteria, and performed an evaluation of the candidates in the context of the defined criteria.

Returning to the focus of decision-making, all three approaches are used to support decision-making within organizations. Although used quite frequently in organizational decision settings, as it applies to the process of effective decision-making, voting for
decision alternatives is the least useful approach. An MCDA approach is much more useful, as it provides data to support an analysis of alternatives.

The CDM approach again is significantly more effective at improving the decision-making process by providing a rich dataset for the analysis of alternatives, and with an open, collective intelligence process, such as the one facilitated by the inqiri solution, the potential for eliciting both evaluation criteria and decision alternatives increases the efficacy of the decision analysis and potential for identifying an optimal decision alternative.

The ability to collect both positive and negative sentiment proved to be one of the more interesting outcomes of the comparison. While a vote is a single, positive data point (i.e. we vote for a candidate) it does not capture the perspective on the other candidates. Even in the simple MCDA approach, the ability to evaluate individual criterion on a positive and negative scale would have advantages. The TOPSIS methodology is a MCDA methodology that incorporates the ability to synthesize both positive and negative input and, although beyond the scope of this paper, the TOPSIS analysis of alternatives produces a simultaneous representation of the geometric relationship between an alternative and the positive and negative ideal for a decision solution space.

In situations where the decision is complex, the alternatives will have positive and negative trade-offs that must be evaluated. This requires a sophisticated MCDA methodology, and will in most cases benefit from some form of CDM, as multiple stakeholders a will have input into the decision.

8. Limitations and future work

This work was limited in focus to the evaluation of the three approaches and the use of rank results from the election as a basis for comparison. While an interesting exercise that allowed us to contrast the three approaches, it was by definition, a simple decision. A more complex decision would provide a more nuanced evaluation of the different decision-making approaches.

The analysis of the rankings was also abbreviated. There are a variety of more statistically valid techniques that would have provided a more sophisticated analysis of the results from the three approaches and their relationships.

Future work could involve a number of avenues across several fields of study. The human element of the CDM approach provides ample opportunity to explore the social, psychological, and cognitive aspects of collaborative decision-making.

With the inherent benefits to organizations of improved decision-making techniques, both the applicability of MCDA and CDM to strategic and operational decision-making should be pursued.

In terms of technology, the effectiveness of tools like inqiri and other decision support solutions that support a CDM approach and tap into collective intelligence can be enhanced and expanded.

One area identified in this paper involves the applicability of predictive market techniques to enhance the predictive effectiveness in the collective decision. The collective intelligence phenomenon produces such compelling results, as illustrated with the race and gender criteria, that it will remain the focus of our future work.

9. References


Figure 1. Criteria Comparison

Figure 2. Bias Analysis