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# Modeling Multi-Objective Multi-Stakeholder Decisions: A Case-Exercise Approach

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The multi-objective multi-stakeholder decision modeling methodology is an effective way to describe and aid context-rich idiosyncratic organizational decision making situations that traditional single attribute decision methodologies can not tackle. The purpose of this paper is to demonstrate how to teach students this methodology as a decision making tool to analyze real-life decision problems using two business decisions as examples (the StarKist decision and the Home Depot case). In particular, we discuss the specific skills students are expected to learn, such as dynamic sensitivity analysis, and typical student questions and errors during case discussion. This methodology has been taught successfully in decision analysis courses both for MBA (including full-time MBA students, business and health care executive MBA students) and undergraduate students.

*Key words*: decision analysis; multi-objective multi-stakeholder decision modeling methodology; StarKist; Home Depot case; strategy; stakeholder analysis
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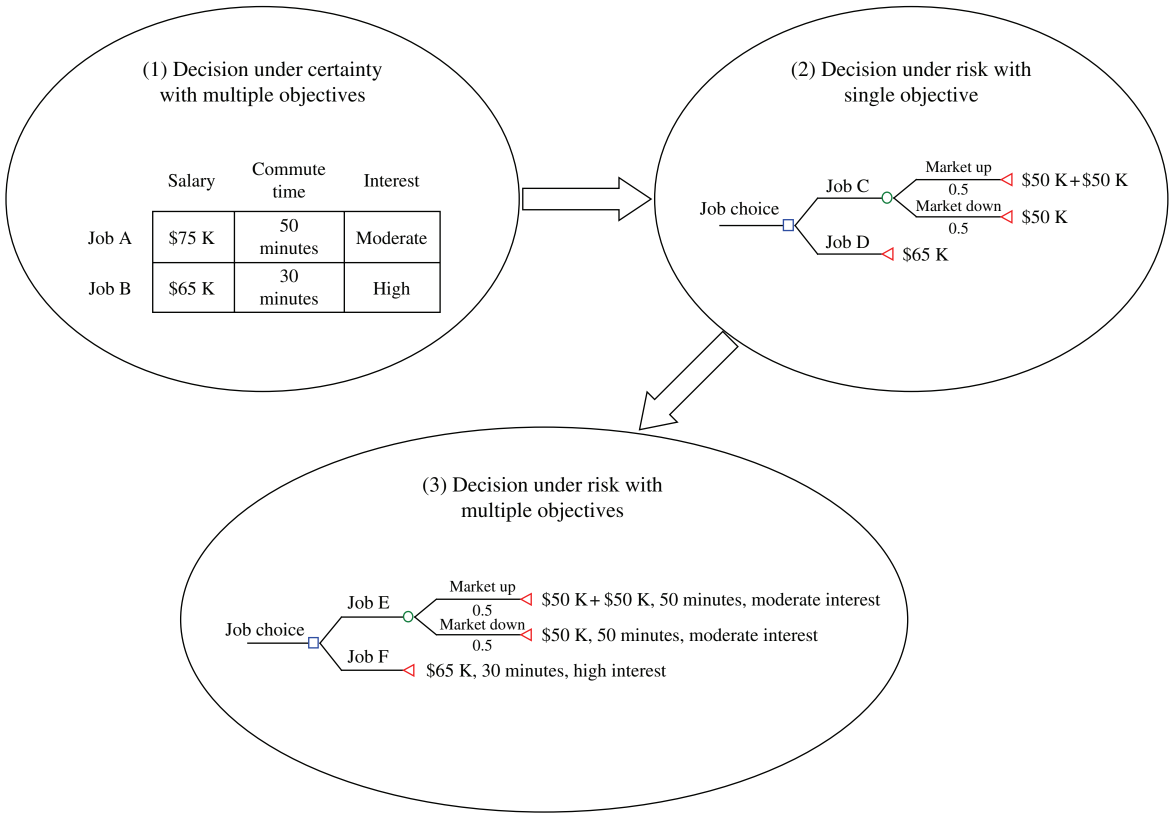
## 1. Introduction

The multi-objective multi-stakeholder modeling methodology, presented by Winn and Keller (2001), links two distinct streams of research: (1) multi-attribute decision analysis (Keeney and Raiffa 1976) and (2) descriptive analysis in the stakeholder literature. It can help decision makers systematically model, analyze, and compare cases of "…context-rich, idiosyncratic organizational decisions that involve multiple sets of objectives of multiple and divergent stakeholders…" (Winn and Keller 2001).

Often classes covering decision analysis focus first on the use of decision trees for aiding single objective decisions, and only briefly discuss how to aid decision makers facing multiple objective decisions in the final class sessions if there is time to cover the topic. In addition, classes generally focus on prescriptive use of decision analysis tools for aiding decision making and do not examine how those tools may be also useful for describing the evolution of prior decisions. Since many significant personal and professional decisions involve multiple objectives and do not need to consider chance events, we have found that it is best to begin a decision analysis course by modeling job choice as a decision under certainty with multiple objectives. For example, if one is facing a job choice decision (Job A versus Job B), the objectives might be to maximize annual salary, minimize daily commute time, maximize interest in job, etc. More specifically, suppose Job A (Job B) offers \$75 K (\$65 K) per year, requires 50 minutes (30 minutes) for commute time, and is moderately (highly) interesting. Then a multiple objective decision analysis process can be used to help make the decision between the two job choices.

The next concept we introduce, decision under risk with a single objective, is used for decisions involving chance events. We can also use a typical job choice example to demonstrate this methodology. For instance, a young man is facing a job choice decision (Job C versus Job D) and his (single) objective is to maximize annual salary. Suppose he takes Job C, in which he will earn \$50 K (base salary) + \$50 K (bonus) per year if the market is good and only \$50 K (base salary) otherwise. The chance event that the market is

**Figure 1 Three Decision Models**




good has a probability of 0.50. On the other hand, if he accepts Job D, he will earn $65 K per year for sure. In this job choice example, one can create a decision tree to help analyze the decision between these two jobs.

The third concept we introduce is decision under risk with multiple objectives. For example, in Hammond's (2006) CK Coolidge Harvard Case, a decision tree (with chance nodes) may be constructed for the different sides of a lawsuit case. Cases such as this can be expanded to consider multiple objectives from different stakeholder perspectives. Figure 1 illustrates the above three concepts we cover in a decision analysis course.

Although there are a number of good decision analysis textbooks (e.g., Clemen 1996 and Kirkwood 1997), plus the popular press book Hammond et al. (1999), there is relatively little practical literature on *how* to teach decision analysis techniques to undergraduate and graduate students majoring in business administration, management science or industrial engineering. A notable exception is Bickel's (2004) paper which demonstrates how to effectively teach fundamental decision making skills, with the novel approach of using baseball examples. To narrow the gap between theory and teaching practice, in this paper we seek to provide operations research and management science professors and doctoral students with a means to introduce our multi-objective multi-stakeholder modeling methodology to their students, particularly in MBA core and elective classes. We believe that this approach would also be useful in MBA strategy classes for stakeholder analysis.

The objectives of teaching multi-objective multi-stakeholder decision modeling are two-fold: (1) enrich the content of the typical course which has one or more lectures on decision analysis by introducing multiple objective multiple stakeholder decisions, since many texts focus on single objective decisions,[1] and specifically, (2) introduce this methodology to students, through in-class exercises and/or homework, to allow students to master this technique as a decision making tool to tackle real-life context-rich decision problems.

In a multiple objective decision analysis approach, a weighted-additive value function is the most commonly used model to evaluate the overall merit of alternatives (a review of the use of the additive value function in decision analysis can be found in Edwards and Barron 1994, Kirkwood 1997 (Chapter 4), Keller

[1] Typical business courses with decision analysis content may cover management science, quantitative methods, decision analysis, statistics, or business strategy. Most will present a decision tree for deciding between risky alternatives with a single objective of maximizing profit or minimizing cost.

and Kirkwood 1999, and Feng and Keller 2006). Specifically, the additive measurable value function combines single-attribute measurable value functions and weights on the objectives to determine the overall value of an alternative, that is

$$v(x_1, x_2, \ldots, x_n) = \sum_{i=1}^{n} w_i v_i(x_i), \quad (1)$$

where $v(x_1, x_2, \ldots, x_n)$ is the overall value for an alternative, $x_i$ is the evaluation measure to assess an alternative's performance on the $i$th objective,[2] $w_i$ is the weight assigned to the $i$th objective, and $v_i(x_i)$ is the single-attribute measurable value function for the $i$th objective. For example, in the job choice example with multiple objectives mentioned previously, the evaluation measure $x_2$ would be the number of minutes in the daily commute. A value function $v_2(x_2)$ could be scaled to range from 0 to 1, with 1 being most preferred (i.e., by convention, value functions are scaled so more preferred alternatives receive a higher value). The value function could be specified by a look-up table to assign values to times (such as 0 minutes is 1, 60 minutes is 0.5, 100 minutes is 0) or by a functional form (such as a linear, exponential, or power function). An example of a linear value function is $v_2(x_2) = (100 - x_2)/100$, which assumes the maximum (worst) commute time is 100 minutes. Also note that the underlying assumptions of using such an additive value function in decision analysis are mutual preferential independence, difference consistency, and difference independence of one objective from the others (see more details from discussion of Theorem 9.23 in Kirkwood 1997). In our Home Depot case presented in this paper, we assume that the above conditions are satisfied and thus use the weighted-additive value function to determine the overall value for each alternative with respect to each stakeholder.

Since each stakeholder group may have different weights on objectives (and even different objectives), after each stakeholder's multi-objective decision model is developed using Equation (1), the models are compared and insights are derived. In Winn and Keller's (2001) model of StarKist's decision, they identified a subsequent revised set of objectives for the key decision maker StarKist after clarifying the objectives of other stakeholders.

One may ask how our approach relates to other operations research models. From the perspective of a linear programming model, Equation (1) is like a decision maker's objective function. Our aim is to maximize the decision maker's overall multi-objective value (the objective function) by completely enumerating the value of each alternative, and then choosing the alternative with the maximum overall value. However, our approach is different from a linear programming model, which identifies a feasible region of a space by a list of linear constraints, within which fall all the possible alternative actions. In contrast, our alternatives can not be conveniently represented as points near each other in a feasible region.[3] We identify the value of all possible actions through complete enumeration by computing the overall value for each alternative using Equation (1). For example, when choosing a job, a person usually has from two to ten possible jobs in the choice set to evaluate. Even though there are relatively few alternatives, job choice decisions can be challenging because they require clarification of preferences regarding tradeoffs between objectives. As presented in this paper, our model is deterministic, but it can be extended to a probabilistic case when there are multiple states of nature.

The rest of the paper is organized as follows. The next section reviews the related literature. Section 3 presents the application of the multi-objective multi-stakeholder decision approach in decision analysis by describing two real business decisions as examples, the StarKist decision and the Home Depot case. In §4, we demonstrate specific skills that we expect students to learn from class discussion. Student questions and responses, typically from MBA classes, are provided in §5. Section 6 concludes the paper.

## 2. Related Literature

Corner and Kirkwood (1991) and Keefer et al. (2004) provide a comprehensive review of the literature on decision analysis applications. In particular, there are several papers that describe the use of a multi-objective decision analysis approach to assist decision making. It has been employed to select a type of transmission conductor in Crawford et al. (1978) and a microcomputer networking approach in Brooks and Kirkwood (1988). Keefer and Kirkwood (1978) evaluated different budget allocation plans for the director of a product engineering group. Keller and Kirkwood (1999) employed a multiple objective decision analysis approach in the merger of two professional societies to form the Institute for Operations Research and the Management Sciences (INFORMS). Feng and Keller (2006) presented a multiple objective decision analysis approach to evaluate different potassium iodide distribution plans for protecting people around a hypothetical local region against potential thyroid cancer

[2] If there are lower level subobjectives for some higher level objectives, this equation is applied to the set of lowest level objectives.

[3] The jobs can be represented as points separately spread out in a multiple dimensional space. For three objectives, the objective function would be a plane within the space, which would be moved in one direction to maximize the overall value.

**Table 1 Representative Papers from the Literature on Multi-Objective Multi-Stakeholder Decisions***

| | Primary stakeholders | Purpose: Describe/ aid** | Scale | Compute overall value? | Number of objectives hierarchies |
|---|---|---|---|---|---|
| StarKist dolphin-free decision (Winn and Keller 2001) | StarKist, environmental groups, fishing fleet. | Describe | + 0 − | No | 3 |
| MacMillan-Bloedel logging practices (Winn and Keller 1999) | MacMillan Bloedel, loggers, environmentalists. | Describe | + 0 − | No | 3 |
| Huntington beach pollution case (Feng et al. 2007b) | Government, local businesses, environmentalists, beach goers and surfers. | Describe | + 0 − | No | 3 |
| Home Depot siting case (Feng et al. 2005) | Home Depot, the city, nearby residents, other residents, complementary businesses, competing businesses. | Describe | 0–10 | Yes | 6 |
| Andy Grove prostate cancer case (Feng et al. 2007a) | Andy Grove, urologist, oncologist, Andy's wife/family, Intel. | Describe | 0–10 | Yes | 5 |
| Los Angeles school board desegregation case (von Winterfeldt and Edwards 1986) | Different stakeholders (for and against) could provide their own weights on objectives and ratings. | Aid | 0–100 | Yes | 1 |
| INFORMS professional society merger (Keller and Kirkwood 1999) | ORSA members, TIMS members, staff. | Aid | −2 to +2 | Yes | 1 |
| Germany's energy policy (Keeney et al. 1987) | Association of German industries, labor unions, the German Society for Nature Protection, etc. | Aid | None | No | 1 final |
| BC Gas (Keeney and McDaniels 1999) | BC Gas, 10 other stakeholder groups. | Aid | Value tradeoffs | Yes (total equivalent cost) | 1 |
| Nuclear incidents and potassium iodide (National Research Council 2004, Feng and Keller 2006) | Each state with close-by nuclear power plant, plant operators, government agencies, American thyroid association, etc. | Aid | 0–10 | Showed example of computation | 1 |

*Entries in the table are presented in the order we discuss in class.
**Describe: The aim was to describe retroactively a decision. Aid: The aim was to aid decision makers in making the decisions.

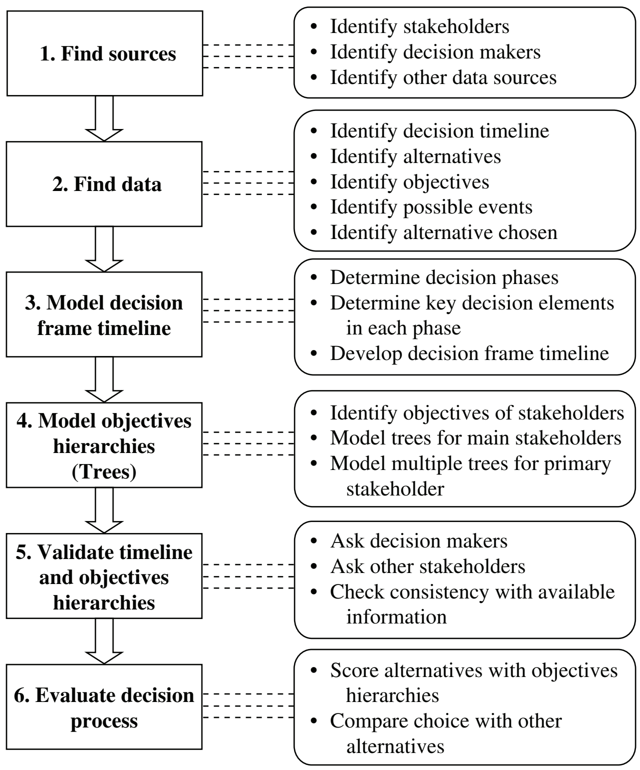
resulting from the release of radioactive iodine from nuclear incidents.

In this paper, we demonstrate how to teach the multi-objective multi-stakeholder modeling methodology through two business decisions. One can use this method as either a descriptive or prescriptive approach in analyzing decision situations. In the StarKist decision (Winn and Keller 2001), and our Home Depot case (Feng et al. 2005), we use it to describe the possible underlying logic of how actual decisions, that involve multiple stakeholders each of whom has multiple objectives, were reached.

Keeney et al. (1987), while developing an objectives hierarchy for the planning of the former West Germany's energy policies, took a slightly different approach than ours to analyze multi-objective multi-stakeholder decisions. They combined each stakeholder's hierarchy into one overall objectives hierarchy for the nation's energy policy, with eight major objectives, such as security of energy supplies, health and safety, national economic impact and environmental impact, etc. von Winterfeldt and Edwards (1986) aided the Los Angeles Unified School District school board to plan for court-mandated desegregation by developing the school board's objectives hierarchy and inviting stakeholder groups to present their own desegregation plans and their own weights on the board's objectives. In contrast to these two projects, we keep each stakeholder's objectives hierarchy separate in both decisions (i.e., the StarKist decision and the Home Depot case). Furthermore, we demonstrate how to perform dynamic sensitivity analysis by using "sliders" embedded in the Excel spreadsheet for the Home Depot case.

We provide in Table 1 a brief review of related literature and cases on multi-objective multi-stakeholder decisions which we mention in our classes. We can see that this approach has become a widely applied decision analysis tool to support decision makers in a variety of decision making settings, such as environmental issues, business projects, societal decisions, and medical decisions. For each item in Table 1, we present the primary stakeholders involved in the decision, the purpose of the research, the method for evaluation of alternatives' outcomes and the number of objectives hierarchies.

**Figure 2** The Multi-Stakeholder Multi-Objective Modeling Method for Examining the Evolution of a Decision




## 3. Two Multi-Objective Multi-Stakeholder Decisions

To achieve our teaching objectives, we chose the paper, "A Modeling Methodology for Multi-objective Multi-stakeholder Decisions" (Winn and Keller 2001) as student reading material. We then spend time in class introducing the decision issues and demonstrating in detail the methodology, as applied by Winn and Keller (2001) who analyzed the StarKist decision to stop fishing for tuna off the west coast of the United States. Figure 2 shows the detailed multiple stakeholder decision evolution modeling method. We developed the Home Depot case so students could practice the application of this methodology. We usually teach both the StarKist decision and the Home Depot case in the first 6 hours of a 30-hour decision analysis elective. We have also taught a reduced size module to undergraduates in a general management introductory class, and at the beginning of a 10-hour undergraduate decision analysis class.

### 3.1. StarKist's Decision

We first present a lecture on StarKist's decision. StarKist is one of the major tuna canners in the U.S. market. They adopted a new tuna fishing method in the 1960s with special nets. However, dolphins were also captured in these fishing nets because dolphins tend to swim near tuna along the west coast of the U.S. In the 1970s, the U.S. introduced legislation to control the number of dolphins killed during tuna fishing. In addition, major environmental groups were escalating their pressure on the canned tuna market leader, StarKist.

StarKist and other stakeholders (including competitors Bumblebee Tuna and Chicken of the Sea, consumers, the San Diego tuna fishing fleet, the news media, and the special interest group Earth Island Institute) were facing the following tuna fishing alternatives: legal quota (maintain current practices and stay within legal limits), limited mortality (step up efforts to reduce the number of dolphins killed), and zero-mortality (no fishing associated with setting nets on dolphins).

This corporate decision can be used as a lecture to illustrate the methodology. Tables 2, 3, and 4 provide a typical spreadsheet with an objectives hierarchy for the stakeholders of StarKist, environmental interest groups and the fishing fleet in San Diego, respectively. For example, in Table 2, Winn and Keller (2001) qualitatively rated the options based on interviews with StarKist executives. Instructors can have the students provide their own ratings and determine if there is a dominant option.

During this lecture, students have had the following two typical questions. First, students have been unsure about what *status quo* meant. The instructor can explain what "to keep the *status quo*" means in a particular decision, and emphasize that there are always at least two alternatives in a decision (i.e., a Go-No Go decision which is Doing Something vs. Keeping the *status quo*). Second, students are not always clear about dominated alternatives or dominating alternatives. The instructor can use an example to explain this concept to them, by showing that an alternative dominates another if it is better than (or tied with) the other on every objective.

### 3.2. Home Depot in San Juan Capistrano[4]

Home Depot proposed to open a retail hardware building products store in San Juan Capistrano, California, to offset a move by competitor Lowe's to nearby San Clemente. The new store would be located on a 15.26 acre property in a strip of industrial oriented land in the southernmost part of San Juan Capistrano. Home Depot had purchased two acres of this land and would need to acquire the rest that was owned by the city.

In our Home Depot case which we created as an in-class case exercise, we identified four options, including building Home Depot, not developing the land,

[4] A teaching note that can be used in the teaching of the Home Depot case (HomeDepotTeachingNote.pdf) can be found at http://ite.pubs.informs.org/.

**Table 2 Decision Alternatives Rated with StarKist's "Business-As-Usual" Objectives Hierarchy**

| StarKist's objectives hierarchy | Decision alternatives: Keep status quo | Reduce dolphin mortality | Go dolphin safe |
|---|---|---|---|
| Maximize profit | | | |
| B1. Minimize cost | | | |
| B1.1. Minimize cost of tuna | + | − | − |
| B1.2. Minimize cost of canning operations | + | − | − |
| B1.3. Minimize cost of transportation logistics | + | + | − |
| B1.4. Maximize quality of tuna and operations | + | + | − |
| B2. Maximize revenue | | | |
| B2.1. Maintain and expand brand loyalty | ? | 0 | + |
| B2.2. Increase customers w/ differentiated product line | ? | ? | ? |
| B3. Optimize industry competitive position | | | |
| B3.1. Capture "first mover" advantages | − | 0 | + |
| B3.2. Hold market share leadership | ? | ? | ? |
| B4. Minimize legal and regulatory interference | | | |
| B4.1. Minimize legal liabilities | ? | 0 | 0 |
| B4.2. Minimize regulatory intervention | − | − | + |
| B5. Maintain favorable stakeholder relations | | | |
| B5.1. Maintain good supplier relations | + | 0 | − |
| B5.2. Maintain good shareholder and banking relations | ? | ? | ? |
| B5.3. Maintain good relations to corporate headquarters | ? | ? | ? |
| B6. Maintain reputation as "good corporate citizen" | − | − | + |

*Notes.* Key for rating alternative's performance on objective: "+": favorable, "0": neutral or balanced, "−": unfavorable, "?": insufficient information. Adapted from material in Winn and Keller (2001), with permission.

building a recreational vehicle park and building specialty retail facilities. We also identified six stakeholders, including the City of San Juan Capistrano, Home Depot, competing local small businesses, complementary local small businesses, nearby residents, and other area residents. Communities throughout the world face similar decisions where "Big Box" retailers such as Wal-Mart or Home Depot propose new locations.

Students can compare the overall value of each option to predict the decision made by the City of San Juan Capistrano. For demonstration, we lay out the steps of running the case in our class and also show

**Table 3 Decision Alternatives Rated for Environmental Interest Groups**

| Environmental interest groups' objectives hierarchy | Decision alternatives: Keep status quo | Reduce dolphin mortality | Go dolphin safe |
|---|---|---|---|
| Protect marine mammals | | | |
| E1. Stop killing of dolphins | | | |
| E1.1. Protect intelligent large marine mammals | − | − | + |
| E1.2. Protect species from extinction | − | ? | + |
| E2. Stop cruelty to dolphins | | | |
| E2.1. Prevent herding by helicopter and detonations | − | ? | + |
| E2.2. Prevent harm from entangling | − | − | + |
| E3. Generate positive public image for cause | | | |
| E3.1. Maximize favorable media coverage | + | + | + |
| E3.2. Generate positive public sentiment | + | + | + |
| E4. Improve prestige of special interest group | | | |
| E4.1. Increase financial support | ? | ? | + |
| E4.2. Gain support from celebrity spokespersons | + | ? | + |

*Notes.* Key for rating alternative's performance on objective: "+": favorable, "0": neutral or balanced, "−": unfavorable, "?": insufficient information. Adapted from material in Winn and Keller (2001), with permission.

**Table 4 Decision Alternatives Rated for Fishing Fleet**

| Fishing fleet's objectives hierarchy | Decision alternatives: Keep status quo | Reduce dolphin mortality | Go dolphin safe |
|---|---|---|---|
| Maintain viable business | | | |
| F1. Maintain profitability | | | |
| F1.1. Maintain lucrative fishing grounds | + | + | − |
| F1.2. Maintain lucrative fishing methods | + | ? | − |
| F1.3. Avoid foreign competition | + | ? | − |
| F2. Maintain livelihood | | | |
| F2.1. Maintain fishing grounds in eastern tropical pacific | + | + | − |
| F2.2. Protect large investments in boats | + | + | − |
| F2.3. Prevent fishing grounds from depletion | ? | + | − |
| F3. Maintain quality of life in local community | | | |
| F3.1. Protect family-owned small businesses and heritage | + | + | − |
| F3.2. Maintain positive image in community | ? | + | + |
| F4. Protect positive image as good global citizen | | | |
| F4.1. Legitimate fishing methods involving dolphins | ? | 0 | − |
| F4.2. Publicize successes in reducing dolphin mortality | 0 | + | + |

*Notes.* Key for rating alternative's performance on objective: "+": favorable, "0": neutral or balanced, "−": unfavorable, "?": insufficient information. Adapted from material in Winn and Keller (2001), with permission.

**Table 5** Decision Alternatives Rated for the City of San Juan Capistrano (Home Depot Case)

| | | | | | Rating on each objective 0 to 10, where 10 is best | | | |
|---|---|---|---|---|---|---|---|---|
| The city of San Juan Capistrano's objectives hierarchy | Calculated weights | Calculated normalized weights | Sliders | Raw weights | Option 1 "Build Home Depot" | Option 2 "Don't develop the land" | Option 3 "Build RV Park" | Option 4 "Build specialty retail" |
| Overall objectives | | | | | | | | |
| C1. Support the city and its residents | | | | | | | | |
| C1.1 Promote job creation | 0.55 | 0.05 | | 20 | 8 | 0 | 1 | 8 |
| C1.2 Keep the city's retail base competitive | | 0.05 | | 20 | 5 | 0 | 0 | 6 |
| C1.3 Provide land sales revenue | | 0.25 | | 100 | 10 | 0 | 0 | 0 |
| C1.4 Provide tax revenue | | 0.15 | | 60 | 10 | 0 | 1 | 2 |
| C1.5 Provide more shopping choice to residents | | 0.03 | | 10 | 4 | 0 | 0 | 6 |
| C1.6 Minimize cost of city services | | 0.03 | | 10 | 2 | 10 | 5 | 3 |
| C2. Enhance viability of community | | | | | | | | |
| C2.1 Provide community service | 0.10 | 0.04 | | 15 | 3 | 0 | 1 | 3 |
| C2.2 Provide regional development | | 0.01 | | 5 | 7 | 0 | 1 | 8 |
| C2.3 Minimize disruption of native land | | 0.05 | | 20 | 1 | 10 | 6 | 3 |
| C3. Optimize social impact on the city | | | | | | | | |
| C3.1 Minimize disruption to daily life | 0.19 | 0.04 | | 15 | 2 | 10 | 6 | 3 |
| C3.2 Minimize crime (day laborer congregation) | | 0.05 | | 20 | 3 | 10 | 4 | 3 |
| C3.3 Minimize overcrowding | | 0.04 | | 15 | 2 | 10 | 2 | 3 |
| C3.4 Minimize traffic congestion | | 0.03 | | 10 | 3 | 10 | 6 | 3 |
| C3.5 Minimize impact on city planning & land use | | 0.04 | | 15 | 3 | 10 | 6 | 3 |
| C4. Minimize adverse environmental impact | | | | | | | | |
| C4.1 Minimize noise | 0.11 | 0.03 | | 10 | 3 | 10 | 5 | 3 |
| C4.2 Minimize hazardous material spills | | 0.01 | | 5 | 3 | 10 | 7 | 4 |
| C4.3 Minimize visual impact | | 0.03 | | 10 | 3 | 7 | 2 | 4 |
| C4.4 Minimize loss of green land | | 0.01 | | 5 | 6 | 10 | 7 | 6 |
| C4.5 Minimize impact on air quality | | 0.01 | | 5 | 6 | 10 | 7 | 6 |
| C4.6 Minimize impact on biological resources | | 0.01 | | 5 | 6 | 10 | 7 | 6 |
| C4.7 Minimize impact on water quality | | 0.01 | | 5 | 6 | 10 | 7 | 6 |
| C5. Minimize health and safety impact | | | | | | | | |
| C5.1 Minimize impact from possible earthquake | 0.05 | 0.03 | | 10 | 4 | 10 | 4 | 4 |
| C5.2 Minimize impact from contaminated material | | 0.01 | | 5 | 3 | 10 | 7 | 4 |
| C5.3 Minimize impact from solid waste | | 0.01 | | 5 | 4 | 8 | 6 | 2 |
| Sum | 1.00 | 1.00 | | 400 | | | | |
| Overall value (sum product of normalized weights times ratings) | | | | | 6.21 | 4.15 | 2.43 | 2.85 |

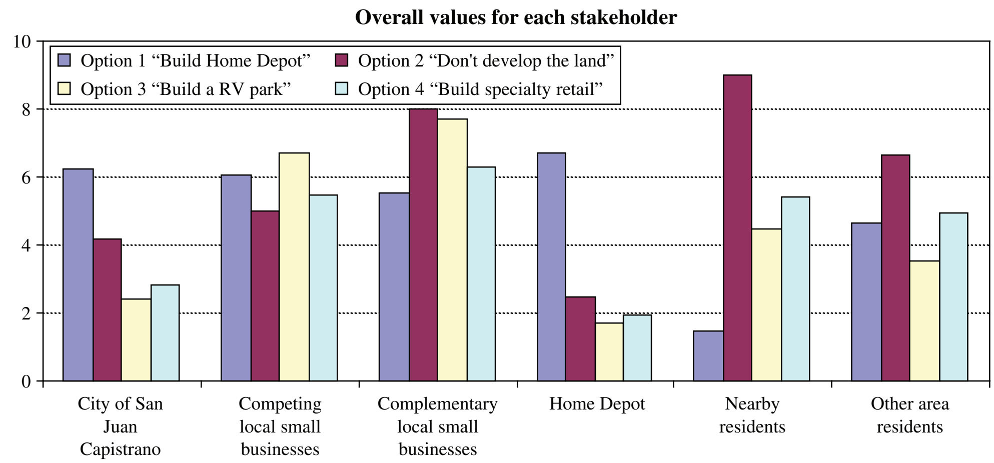
a sample decision alternatives worksheet in Table 5[5] We first assign the students to six groups representing different stakeholders and then ask the groups to do the following:

- Brainstorm the objectives of the stakeholder. Create a hierarchy of objectives by grouping related objectives together.
- Put the objectives in the spreadsheet.
- Rate the options' performance on each objective on a scale from 0 to 10, with 10 being best.
- Ask the groups to make their own judgment of the weights to put on the lower-level objectives (also called "subobjectives") in the spreadsheet, which has been set up to take raw weights and normalize them to sum to 1. It then computes the Excel SUMPRODUCT of the weights and ratings on each objective (i.e., Equation (1)) and then displays the values of different alternatives on a newly created bar graph.
- Ask them to answer all the questions and post the completed spreadsheet file to our school's intranet website.
- Ask each group to determine the best option based on the analysis.

During the class discussion, we collect the evaluation results from all stakeholder groups and make a summary file to create bar charts in Excel displaying

[5] The Excel file that can be used for students to evaluate their decisions for the Home Depot case (HomeDepotCase.xls) can be found at http://ite.pubs.informs.org/.

**Figure 3** Sample Evaluation of Different Alternatives for Different Stakeholders in the Home Depot Case




the results[6] Figure 3 summarizes the sample overall values of different alternatives for all six stakeholders (this is based on the case discussion results from a merged fully employed/full-time MBA decision analysis class in Fall 2006, at the Paul Merage School of Business, University of California, Irvine). For example, from Figure 3, we can see that the option of "don't develop the land" was the most preferred three of the stakeholders, and that the Home Depot stakeholder group preferred to "build the retail store." Then, the class is asked as a whole to take a final vote among the options to predict the actual vote.

After the class discussion, we show the students the actual vote result. The San Juan Capistrano vote was 69% against the city selling the land to the Home Depot (7,137 people) and 31% in favor (3,208 people) according to the *Los Angeles Times* (11/7/02, p. B11).[7] Usually a majority of students also vote against selling the land.

When we first made this case, we had constructed a stakeholder group representing "Other Local Businesses." Then the students asked for clarification by asking "Is our business a competitor of Home Depot or a complementary business?" We then created two stakeholder groups for competing and complementary local businesses.

## 3.3. Multi-Stakeholder Modeling Issues

We next discuss with students multi-stakeholder decision modeling issues. In both the StarKist and Home Depot decision models, each stakeholder had his own set of objectives, which were distinct from other stakeholders. Further, in Winn and Keller (2001), there are three objectives hierarchies for StarKist, as the decision evolved: In the business-as-usual stage, the strategic planning stage and in crisis mode, with more detail from other stakeholders. Depending on the situation, it may be possible to combine all the stakeholders' objectives into one master list. For example, Keeney (1987) presented an approach to first elicit and structure the objectives hierarchy with respect to each stakeholder for a decision problem of public interest and then integrate them into an overall set of objectives.

In each decision situation, the modeler faces a number of choices, such as (a) whether to combine all objectives into a master list or keep each stakeholder's objectives separate, (b) whether to assign weights to objectives or stop after creating the objectives hierarchies, (c) whether to allow each stakeholder to assign different weights to a master list of objectives, and (d) whether to combine the overall values assigned to alternatives by each stakeholder. For a specific decision problem involving multiple stakeholders, it is generally appropriate to consider an overall objectives hierarchy for all stakeholders if there is no significant conflict of interest in major categories of objectives among all separate objectives hierarchies of different stakeholders. When a master list of objectives is structured for all stakeholders, a common approach is to have major stakeholders agree on the weights assigned to objectives through open discussion. This facilitates communication among stakeholders and generation of potential alternatives. Otherwise, it is feasible to keep the objectives hierarchy of each stakeholder separate, which allows the primary decision maker to understand clearly and exactly the concerns and evaluations of alternatives from each stakeholder's own perspective. Clear insights for decision makers may be drawn when all stakeholders make the same recommendation on preferred actions based on their separate objectives hier-

[6] The Excel file used to summarize the evaluation results from all stakeholder groups (SummaryofHomeDepotCase.xls) can be found at http://ite.pubs.informs.org/.

[7] This website describes the issues and the results of the advisory vote in November 2002 by city residents on this proposal: http://www.smartvoter.org/2002/11/05/ca/or/meas/DD/.

archies. However, decision makers may need to spend more time thinking about final decisions if there are remarkable differences in recommended alternatives among all stakeholders. In some cases, the overall value of an alternative might be computed by averaging the values from important stakeholders. To summarize, modelers need to make different modeling choices in each case depending on the specific characteristics of the situation.

## 4. Specific Skills that One Can Expect the Students to Learn

After introducing the fundamental techniques, we give the students the chance to practice making their own decisions by playing the role of stakeholders. Having students do this greatly enhances their understanding of the method and leads to expanded discussion of the relative strengths and weaknesses of such a methodology. In particular, we expect them to learn the following skills from the discussion.

(1) Learn to assign value ratings to how well each option satisfies each objective.[8] With respect to the multi-objective multi-stakeholder modeling methodology, there are different sets of scales to evaluate ratings of each option regarding each objective. One is a qualitative scale (e.g. "+," "−," "0," and "?"), where these codes stand for "favorable," "unfavorable," "neutral or balanced," and "insufficient information," respectively.[9] Winn and Keller (2001) used a qualitative scale in the StarKist decision. In contrast to this qualitative scale, a 0–10 scale is often used, such as in our Home Depot case, to rate the options quantitatively with respect to each objective, where 0 is the worst and 10 is the best.

(2) Learn to creatively generate objectives and structure them into a hierarchy of objectives. Keeney (1992) provided guidelines for constructing objectives for evaluating decision alternatives. From the discussion, students will be prepared to generate objectives and lower-level objectives on their own. Note that for some stakeholders, several objectives in our cases may have been pre-developed for the convenience of case discussion. Students may not understand or may disagree with certain objectives. The instructor can therefore guide the students to think about whether the objectives make sense.

[8] Subsequent lectures could cover assessment of single attribute measurable value functions. Here, direct rating of the value of an alternative action on an objective is sufficient.

[9] To make the qualitative scale more straightforward, sometimes color codes are used instead. For example, four different colors (e.g. green (+), red (−), yellow (0), and grey (?)) can be used to represent the four levels of ratings on options with regard to each objective. These color codes are commonly used in traffic lights (e.g. green light: go, red light: stop, yellow light: yield), which helps students understand the rating scales quickly.

(3) Learn to use the "swing weight" approach to generate weights on objectives. Borcherding et al. (1991) discussed four weighting methods used in decision analysis, including the swing weight method, the ratio method, the tradeoff method, and the pricing out method. We use the swing weight method in the Home Depot case since it provides a way to assess the relative importance of objectives and it allows us to explicitly consider the range of possible performance on an objective by embedding sliders (i.e., "swinging" the range used to obtain the weights) in a Microsoft Excel spreadsheet.

By using the swing weight method, the objectives are placed in rank order by importance and raw weights are assigned to the objectives on a 0–100 basis, where 0 is the least important and 100 is the most important. Then the raw weights are normalized to add up to 1 (or 100%) and each objective thus receives a calculated normalized weight. Since the weight on an objective depends on the range that is being contemplated, the swing weight method is developed to highlight this key point. That is, using the swing weight method, a weight does not directly measure the relative importance of an objective, but the relative importance of the range of possible performance on the objective. If a person merely directly assigns a weight to each objective, without considering the range of possible performance on an objective, the resulting weights may not correctly reflect his or her preferences. A student might say that maximizing salary and minimizing commute time are equally weighted. However, in truth, the student should put different weights on these objectives if their ranges differ. The example in the next paragraph illustrates how to assess weights by carefully eliciting the tradeoffs between these objectives.

We use the following example to demonstrate how the swing weight method generally works. Suppose salary can range or "swing" from \$40 K to \$200 K and commute time ranges from 10 minutes to 60 minutes. Suppose a student is presented with two hypothetical options: Job M (for Money): \$200 K, but a 60-minute commute versus Job T (for Time) a 10-minute commute, but only \$40 K. A student who chooses Job M is saying that making the most money is more important than saving time in commuting, *for the ranges that were contemplated*. With the swing weight method, for just these two objectives, this student would be instructed to consider Job M as having an overall value of 100 (as the best of these two hypothetical options). The Worst Case Job WC would have the bad salary (\$40 K) and the bad commute (60 minutes). This student would be told this Job WC has the overall value of 0. Then, he'd be asked this question: on a scale from 0 to 100, what overall value would you give Job T? Suppose he says: "I'd say this Job T has an

**Table 6 Decision Alternatives Rated for Home Depot (Home Depot Case)**

| | | | | | Rating on each objective 0 to 10, where 10 is best | | | |
|---|---|---|---|---|---|---|---|---|
| Home depot's objectives hierarchy | Calculated weights | Calculated normalized weights | Sliders | Raw weights | Option 1 "Build Home Depot" | Option 2 "Don't develop the land" | Option 3 "Build RV Park" | Option 4 "Build specialty retail" |
| Overall objectives | | | | | | | | |
| H1. Offset Lowe's move to San Clemente | | | | | | | | |
| H1.1 Capture market share | | 0.10 | | 75 | 10 | 0 | 0 | 0 |
| H1.2 Establish market presence | | 0.06 | | 50 | 10 | 0 | 0 | 0 |
| H1.3 Maintain market dominance | 0.31 | 0.03 | | 20 | 8 | 0 | 0 | 0 |
| H1.4 Maintain competitiveness | | 0.03 | | 25 | 5 | 5 | 2 | 4 |
| H1.5 Maintain small market | | 0.09 | | 70 | 4 | 6 | 7 | 7 |
| H2. Maximize profitability | | | | | | | | |
| H2.1 Expand operations | | 0.10 | | 80 | 10 | 0 | 0 | 0 |
| H2.2 Increase product margins | 0.37 | 0.03 | | 25 | 7 | 0 | 0 | 0 |
| H2.3 Increase revenue | | 0.13 | | 100 | 9 | 0 | 0 | 0 |
| H2.4 Maximize land use | | 0.11 | | 85 | 2 | 8 | 5 | 6 |
| H3. Be a good corporate citizen | | | | | | | | |
| H3.1 Maximize community involvement | | 0.12 | | 90 | 10 | 0 | 0 | 0 |
| H3.2 Provide source of tax revenue to city | | 0.03 | | 25 | 1 | 0 | 0 | 0 |
| H3.3 Promote growth of local economy | 0.32 | 0.04 | | 30 | 2 | 0 | 0 | 0 |
| H3.4 Increase local taxes | | 0.06 | | 50 | 3 | 7 | 4 | 5 |
| H3.5 Increase crime rate | | 0.07 | | 55 | 4 | 6 | 3 | 3 |
| Sum | 1.00 | 1.00 | | 780 | | | | |
| Overall value (sum product of normalized weights times ratings) | | | | | 6.69 | 2.44 | 1.71 | 1.94 |

overall value of 50." From this response, one can use the swing weight approach to infer the normalized weight on salary for this student is $100/(100+50) = 2/3 = 0.66$ and the normalized weight on commuting time is $50/(100+50) = 1/3 = 0.33$. See more details on the logic behind the swing weight method in textbooks by Clemen (1996), Kirkwood (1997), and von Winterfeldt and Edwards (1986).

Students can learn the swing weight method in the Home Depot case. For example, the City of San Juan Capistrano group put a raw weight of 100 for subobjective C1.3 in the raw weights column in Table 5. This response means that "providing land sales revenue" was the most important objective among the 24 subobjectives, in the sense that if all subobjectives were at their worst level, this one was the first to be chosen to swing from its lowest level (say, $0 extra revenue) to its highest level (say, $40 million extra revenue) holding all other subobjectives at their lowest levels. Then all other subobjectives have weights which are between 0 and 100, depending on their ranges. Thus, for example subobjective C1.4, "providing tax revenue," was assigned a raw weight of 60. So, swinging "providing tax revenue" from its worst level (say, $0 extra dollars per year) to its best level (say, $1 million extra per year) has a value of 60, compared with a value of 100 for swinging "providing land sales revenue" from its worst level to its best level. This swing weight method requires one judgment for each of the 24 subobjectives. Each judgment compares a worst-case alternative (with value = 0) with all objectives held at their lowest level with an alternative with one objective at its highest level and all other objectives at their lowest levels. After all the raw weights are determined, they are normalized to add to 1.

(4) Learn to do sensitivity analysis on weights, using "sliders" created in the Excel software.[10] Sensitivity analysis on probabilities of states of nature in single objective decisions under risk has been widely discussed in the literature and textbooks in decision science. However, there is relatively little discussion on sensitivity analysis on weights. In the Home Depot case, sliders are created in Excel for students to do sensitivity analysis. (We provide a sample of the use of sliders in Tables 5 and 6). With the aid of sliders, students can adjust the raw weights on objectives dynamically and as a result, the overall values of options may change as the calculated normalized weight on each objective varies. Students may see that the best option may switch from one to another as they move the sliders to change the importance

[10] Sliders can be easily created by using the controls menu in Excel 2003, which calls them scroll bars. Sliders can also be made using the forms menu in Excel 2003. Spin buttons are another way of allowing dynamic input.

weights on the objectives. Therefore, the use of sliders in Excel offers a convenient means to perform "dynamic" sensitivity analysis on weights and adds another sensitivity analysis tool for decision scientists. Students often ask us for a generic Excel spreadsheet template with "sliders" that they can use for their future decisions.

(5) Learn to compare overall values of options, using the SUMPRODUCT function in Excel. Once students fill out the spreadsheet, the SUMPRODUCT function will calculate the overall value for each option and then students can choose the alternative with the highest overall value as their recommendable option. As discussed earlier, we assume that an additive multiattribute measurable value function is appropriate. Note that in the StarKist decision without quantitative analysis, we ask students holistically what option is preferred based on their qualitative ratings on options with respect to each objective. Furthermore, students may not understand what a "dominant option" or "dominated option" means even if given a brief definition. We explain that no matter what weights there are on objectives, an option which is worse than or tied with another on each objective is dominated and can be eliminated. This discussion then leads to the idea of using weights on objectives.

(6) Learn to compare and contrast results from different stakeholder groups. After each group completes evaluating the options in the Home Depot case from the perspective of one specific stakeholder, we collect the calculated overall values for each option from each group into a summary file to create bar charts showing results. Then, we ask the students to compare and contrast the evaluation results from different stakeholder groups. We tell the students that a next step in the modeling process could be to refine a group's objectives or alternative actions based on insights about other group's objectives.

(7) Based on our experience, doing the Home Depot case could take a great deal of class time if students were extremely uncertain about what scale value should be assigned to an alternative's achievement on particular objectives. Students also sometimes spent a lot of time on generating subobjectives.

## 5. Student Questions and Responses

Students' questions help us discover what they do and don't understand. These are typical MBA comments.

(1) Students might not understand the difference between ratings of values and weights on subobjectives. Weights are assigned to represent the importance of each specific subobjective, while ratings are given to each of the alternatives based on this subobjective (a rating is defined to be the single objective value function level attained by an alternative on that objective). We used a 0–10 scale for value ratings so there is less confusion with raw swing weights which range from 0 to 100. The instructor can make it clear before students fill out the spreadsheet.

(2) The same (tied) weights assigned to different subobjectives are allowed (since students often tend to think weights should be in a descending order). Moreover, with regard to one subobjective, students can also give the same ratings to different alternatives.

(3) Students don't have to complete filling out all the blanks of subobjectives. Objectives don't have to have the same number of subobjectives, but if an objective is subdivided, there should be two or more subobjectives.

(4) Students might generate inappropriate subobjectives for one specific objective. For example, in Andy Grove's prostate cancer treatment decision (in Feng et al. 2007a), "minimize side effects" is an important objective for the patient group. Students might create three subobjectives for this general objective, including "few or no side effects," "moderate amount of side effects," and "many side effects." However, these are just three levels of the side effects objective and those levels would be reflected in the value ratings assigned to each alternative action. Therefore, it is not appropriate to have these three subobjectives following this specific objective.

(5) Students might be confused about whether they should start with the lowest or highest level subobjectives when computing swing weights. The instructor can remind them that they only need to assess the lowest-level subobjectives, since our spreadsheet is set up to calculate the rest. Note that one can also use a top-down approach, but that is not the way our spreadsheet is set up.

(6) Students might ask if they can add more alternatives. At this point we discuss how the process of generating objectives and consider different stakeholders' viewpoints can aid in generating creative new alternatives. See for example, Feng and Keller (2006, p. 86), for a discussion of generation of new options.

## 6. Conclusion

The multi-objective multi-stakeholder decision modeling method is an effective way to describe and aid context-rich idiosyncratic organizational decision making that traditional single attribute decision methodologies can not tackle. We have taught the Home Depot case successfully as an in-class exercise in MBA elective courses on decision analysis (with about 40 students), to full-time MBA students as well as business and health care executives. We have also successfully taught it in a small freshman seminar and a large undergraduate business lecture course. It would also work as an in-class case in masters and undergraduate level classes in engineering, business, and OR/MS, as long as the class is small enough to divide students into groups and groups have access to computers to use the Excel file which contains the Home Depot case. Or, it could be assigned as a take-home case, followed by discussion of results in a subsequent class. Therefore, we believe it is important and feasible to include this method in the teaching materials for decision analysis.

The purpose of this paper is to show how we teach this decision analysis modeling method. We expect students to learn how to evaluate decisions under certainty with multiple objectives and multiple stakeholders. In particular, students can learn how to generate an objectives hierarchy, rate options with respect to objectives using qualitative or quantitative scales, assign weights for objectives, determine the preferred alternative action based on calculated overall values of options and do sensitivity analysis. Furthermore, we also hope that this methodology will be enriched and adapted as more people use it in practice.

We have found that the hands-on practice in class using sliders in Excel, coupled with a term project using this approach, has resulted in students' being able to successfully use these techniques in their own work environments. For example, an alumnus in human resources used this for screening job applicants and one in corporate finance used it for capital budgeting. Alumni have contacted us years later and asked us to send them the course materials so they can modify them for a current business decision.

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