Survey of Value-Focused Thinking: Applications, Research Developments, and Areas for Future Research

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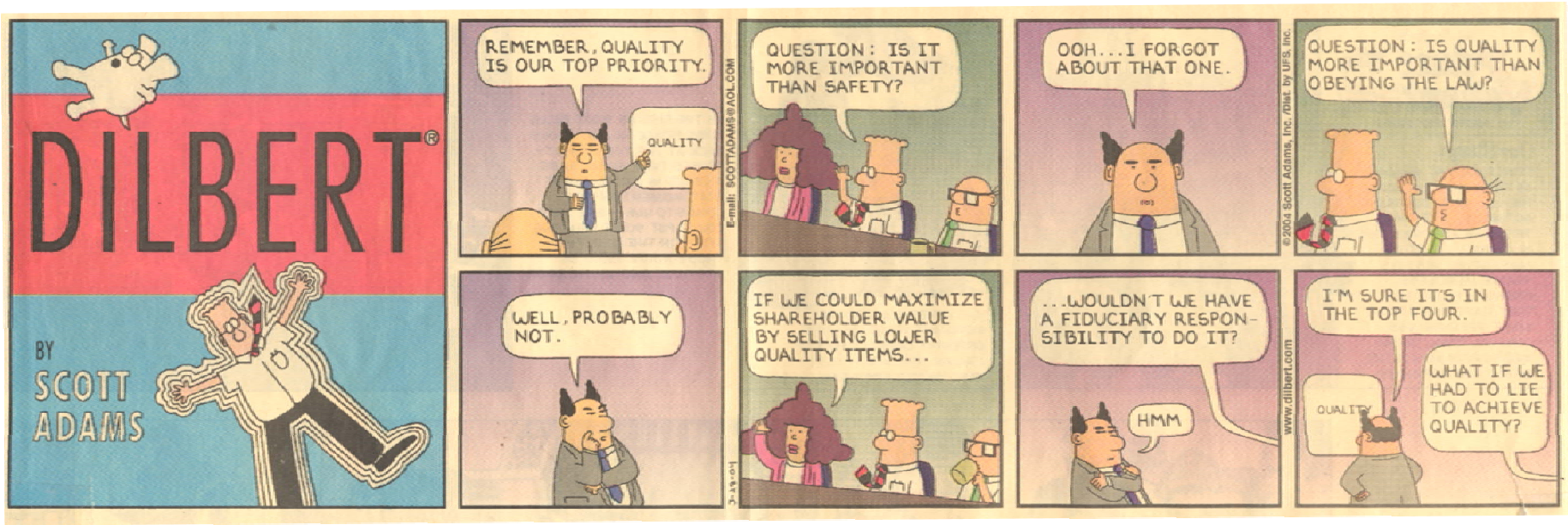
Agenda

- Purpose
- Method
- Research Questions
- Findings
- Summary
- Conclusion



Purpose

- While others published survey articles on MCDA or MCDA and decision analysis, there have been **no comprehensive survey articles of the Value-Focused Thinking (VFT) applications and research developments.**
- The purpose of our VFT review paper is to provide a comprehensive summary of the **significant applications, describe the main research developments, and identify areas for future research**.

Author Objectives

- In the spirit of VFT, the authors began by thinking about their objectives. Since the authors were a mix of junior and senior faculty, we had a diverse set of objectives.
  - Respond to a request from a friend who is an Associate Editor of MCDA
  - Help colleagues learn about an important philosophy
  - Increase our individual understanding of the field
  - Learn about applications of VFT in private and public organizations
  - Learn about application of VFT in the global community
  - Obtain examples and insights that we can use in our decision analysis courses
  - Provide useful information for other scholars
  - Help identify areas for future research in VFT
  - Build professional reputation of decision analysis research at West Point

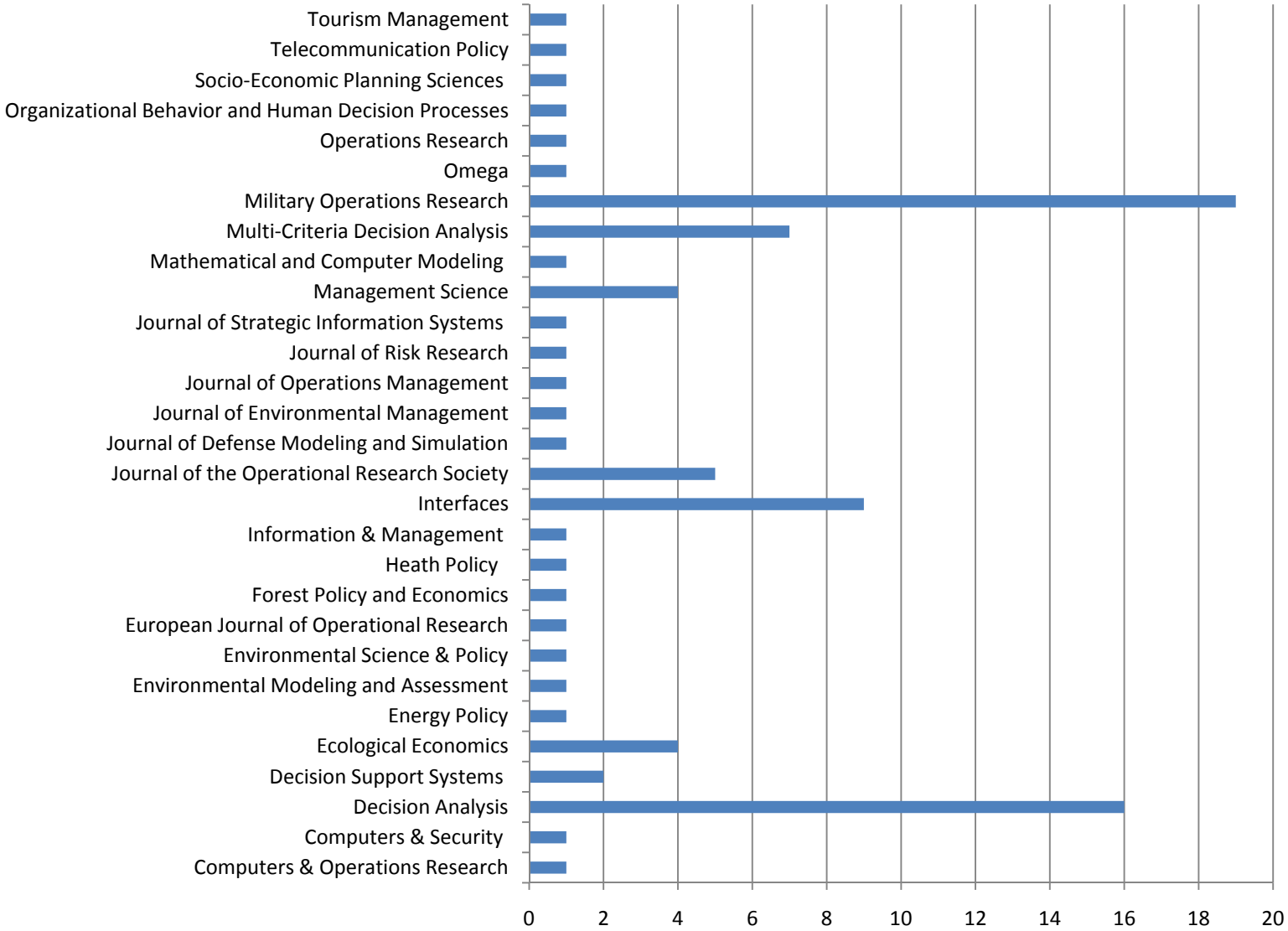
Method

- Used VFT as key word and reviewed articles that cited Keeney's 1992 VFT book.
- Consider publications from 1992 – 2010.
- Limited to English language journals.
- Used major operations research journals.
- Used Google Scholar to supplement.
- Developed and refined the research questions.

Research Questions

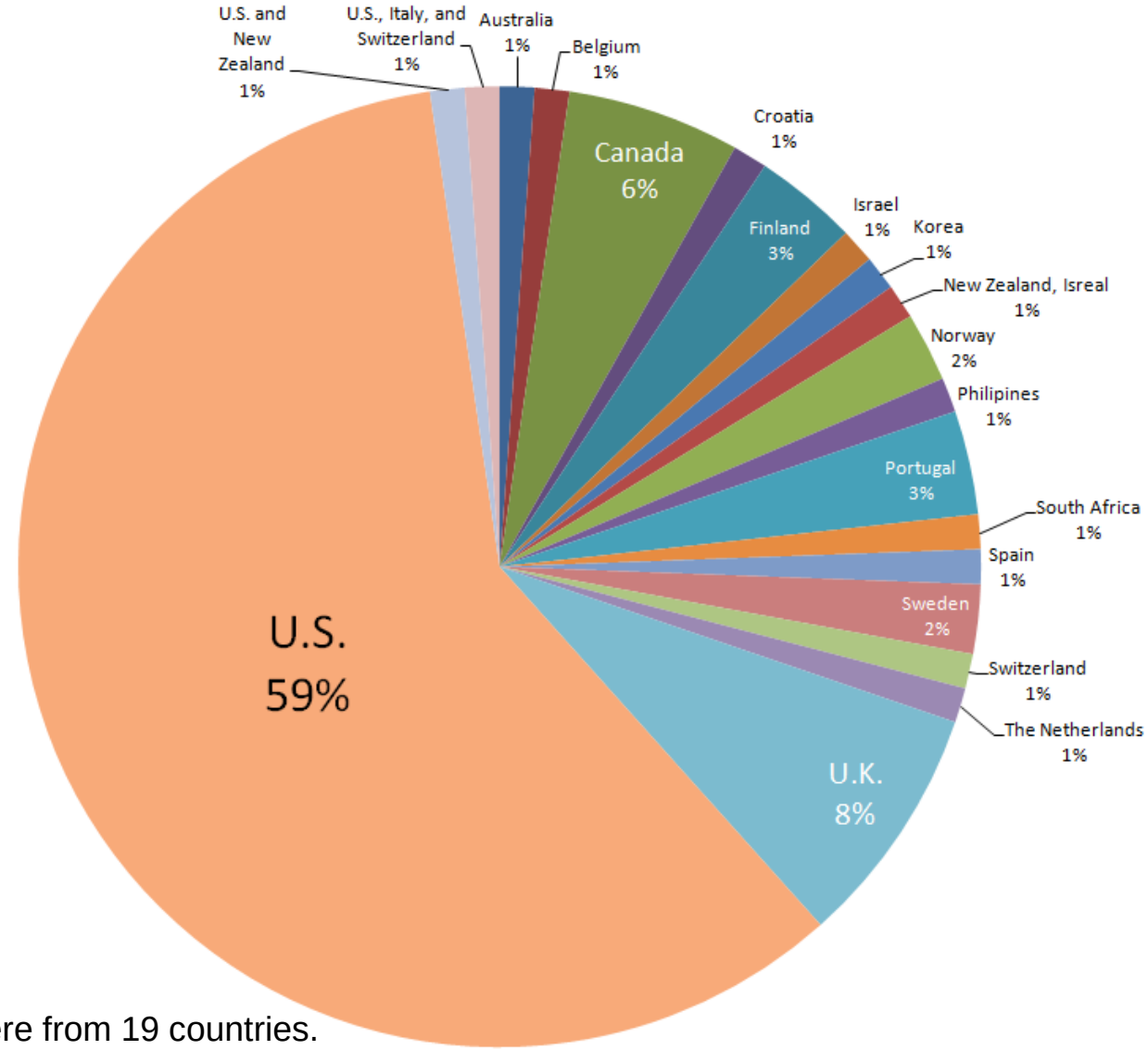
- What journal was the article published in?
- What was the country of the authors?
- When published?
- What type of article?
- What type of decision was described?
- Was this paper based on dissertation or masters degree research?
- How many times has the paper been cited?
- What was the problem domain?
- Was the value/utility model used to evaluate alternatives?
- Was VFT used to design or improve alternatives?
- Who were the clients for the work?
- What was the size of decision space?
- What mathematical model was used?
- How many value/utility measures were used?
- What type of resource modeling was used?
- What type of uncertainty modeling was used?
- What other operations research/management science techniques were used?
- What was the impact of use of VFT?
- What new methods were developed?

Journals



- Using our criteria, 29 journals, 88 articles have published VFT articles.
- MOR is the journal with the largest number of publications.

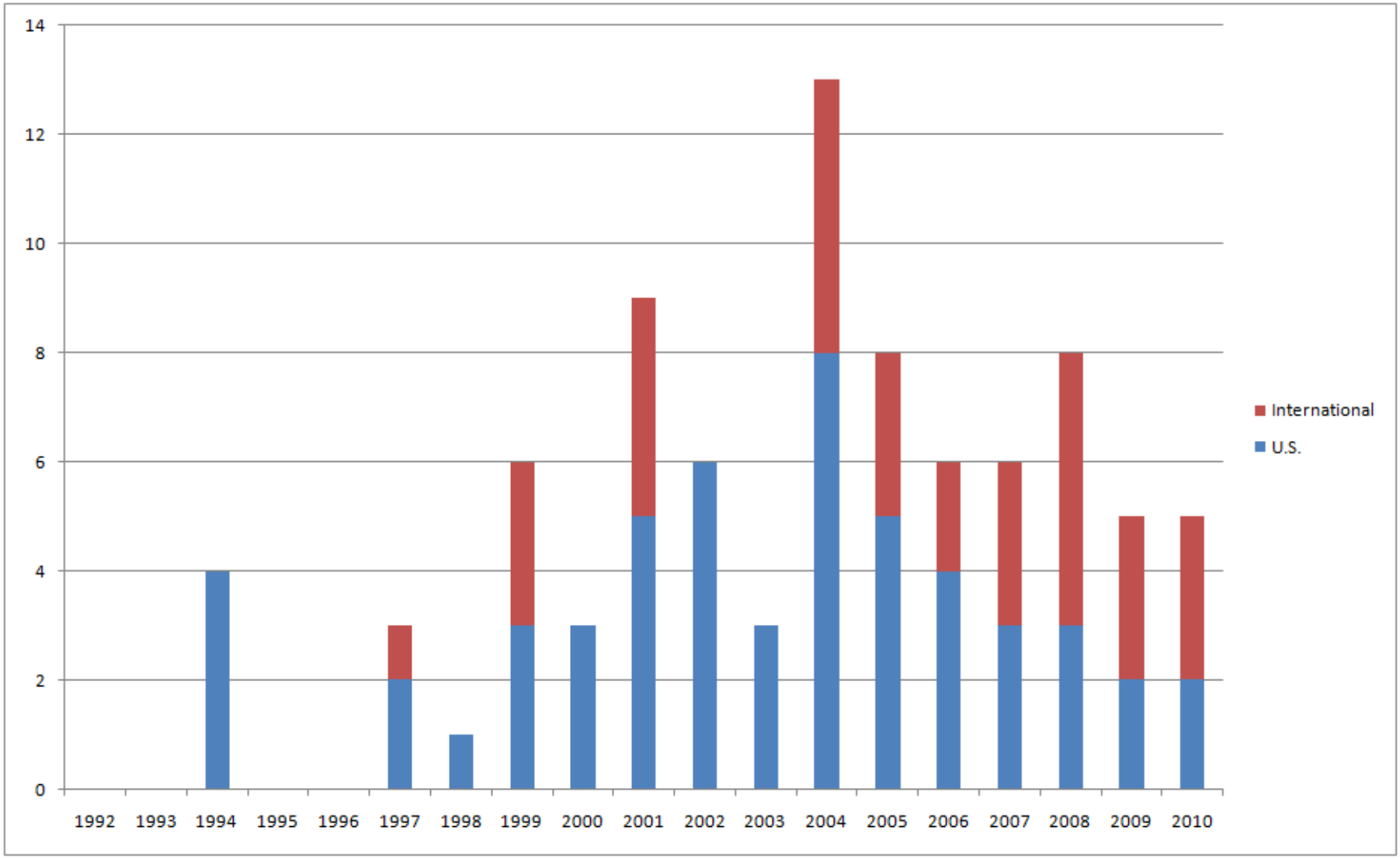
Country of Authors



- Authors were from 19 countries.
- U.S. (51 articles), U.K. (7 articles), and Canada (5 articles) have largest percentages.
- Keeney: authored/co-authored 10 out of the 51 U.S. articles (~20%).

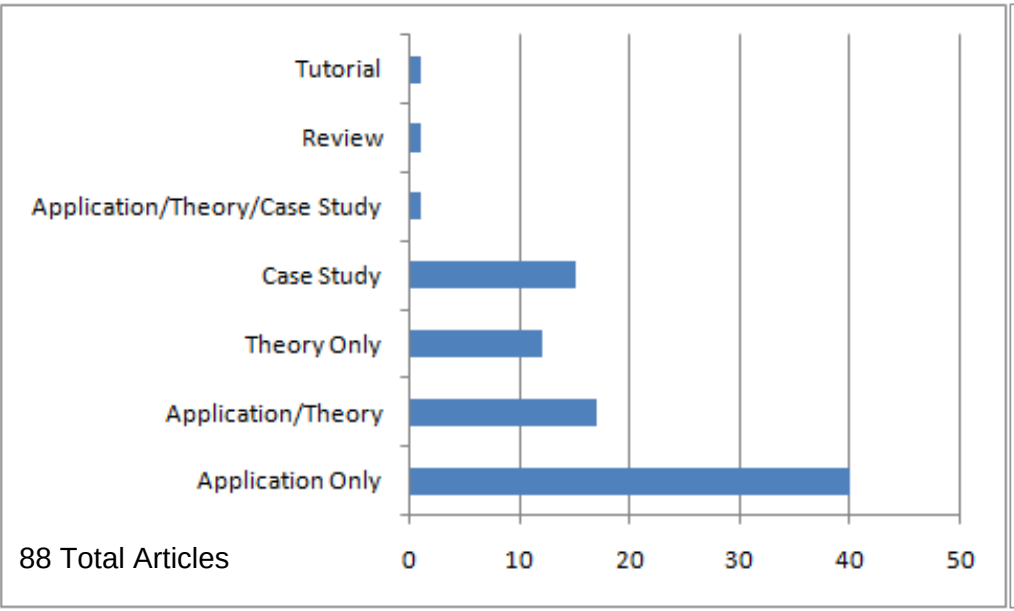
Only surveyed English language journals

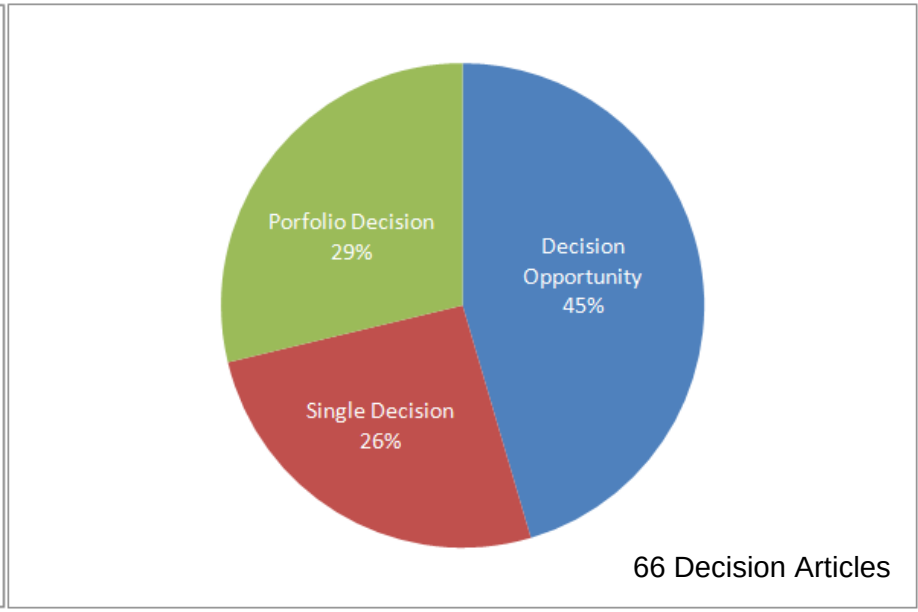
Articles Published Over Time



- Publications grew over time, peaking in 2004.
- Steady amount of international articles starting in 2004.

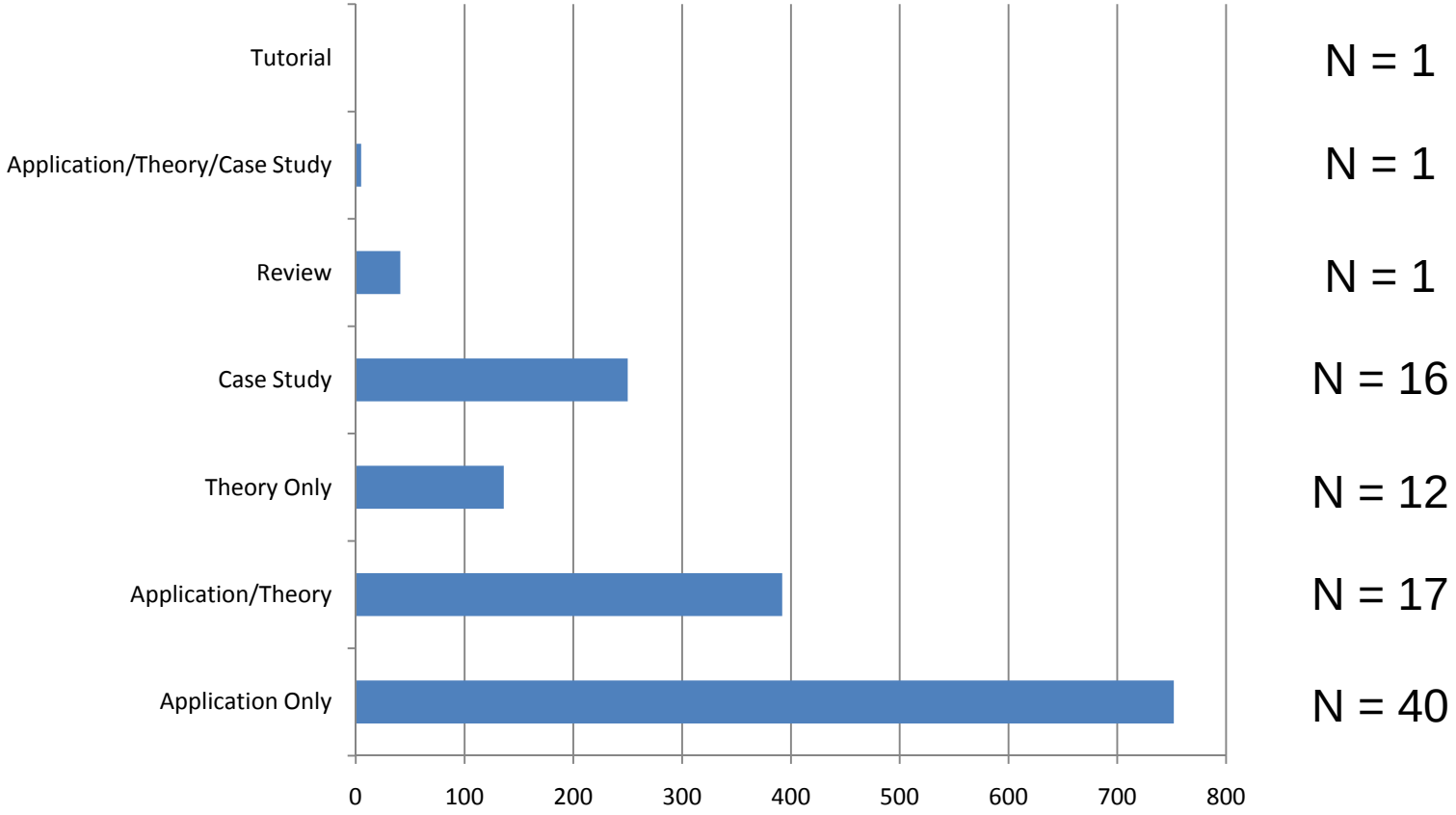
Type of Article and Decision





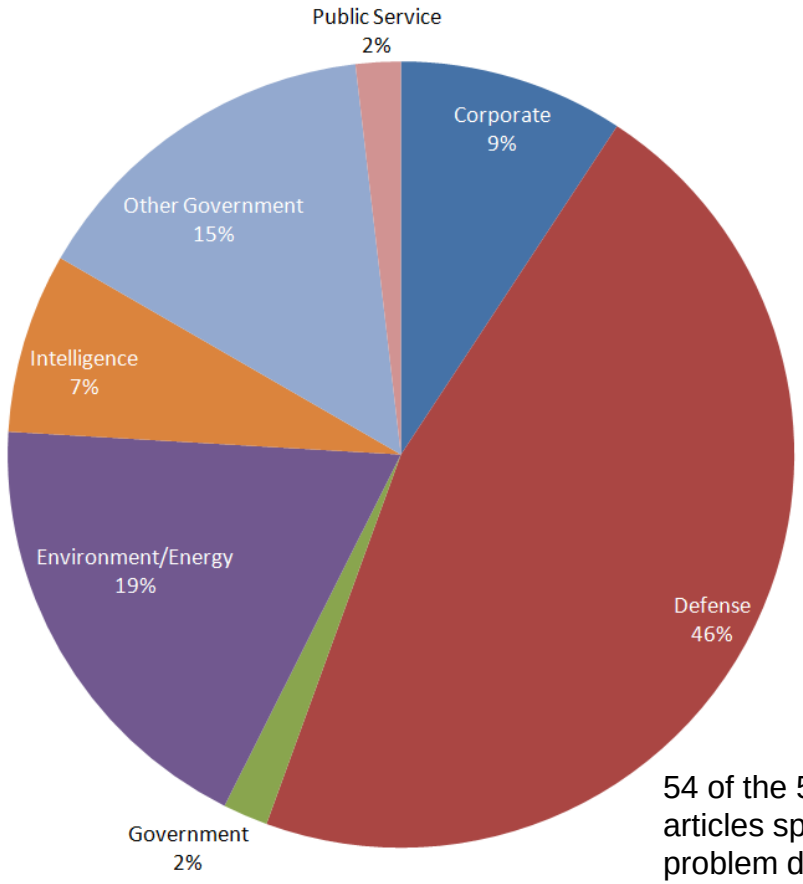
- Type of Article:
  - Majority of articles were application articles.
  - Significant number of theory and case study papers.
- Type of Decision:
  - 45% of the decision articles used VFT to analyze decision opportunities.
  - Portfolio decisions are slightly larger than single decision applications.
- PhD/MS Research
  - 12 papers – All in application vs. theory.

Article Citations (Google Scholar)

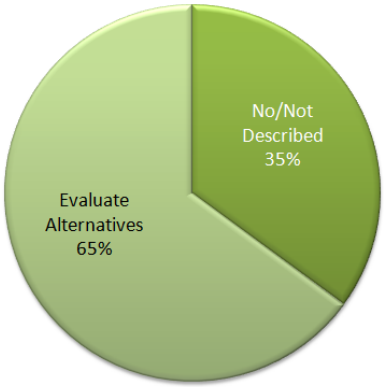


- Application articles are cited more than theory papers.
- 42% of citations are from Ralph Keeney's papers. (He authored/co-authored 10 papers.)
- 2 of Keeney's papers make up 36% of the total citations.

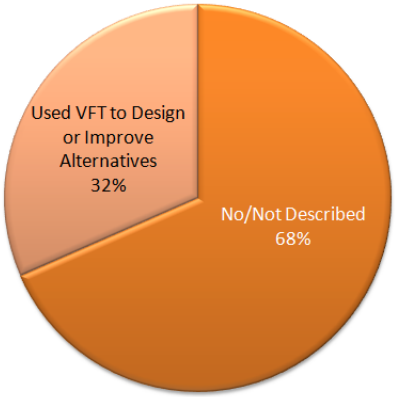
Applications – Problem Domains & Use of VFT



54 of the 57 application articles specified a problem domain



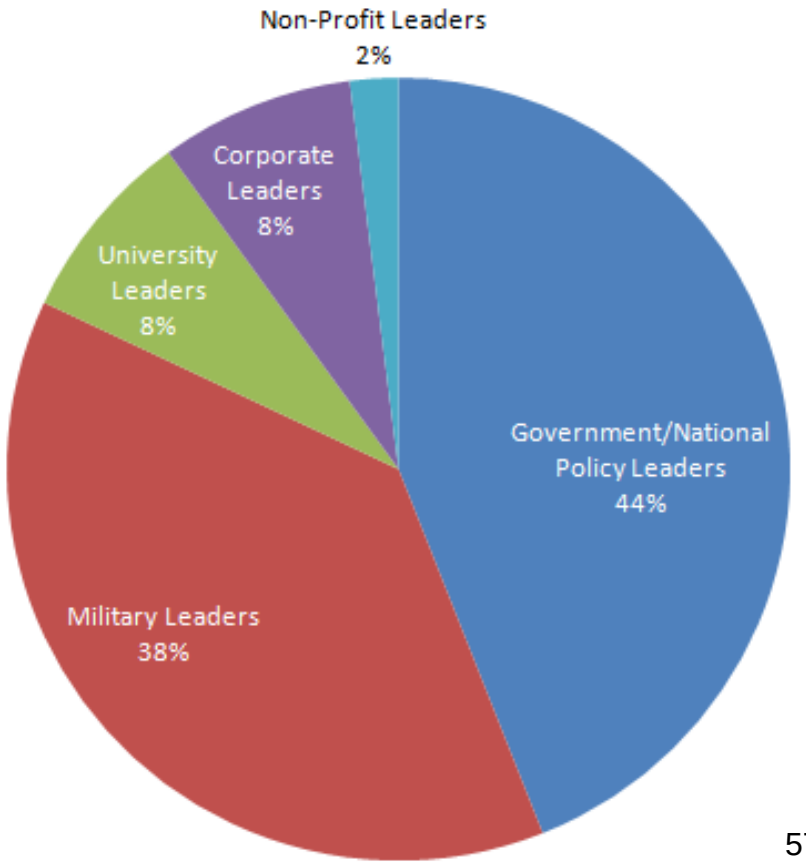
57 application articles



57 application articles

- VFT has been used in a diverse set of problem domains.
- Defense is the largest domain for published applications.
- 9% of the problem domains are corporate.
- 65% use VFT to evaluate alternatives.
- Only 32% described use of VFT to design or improve alternatives.

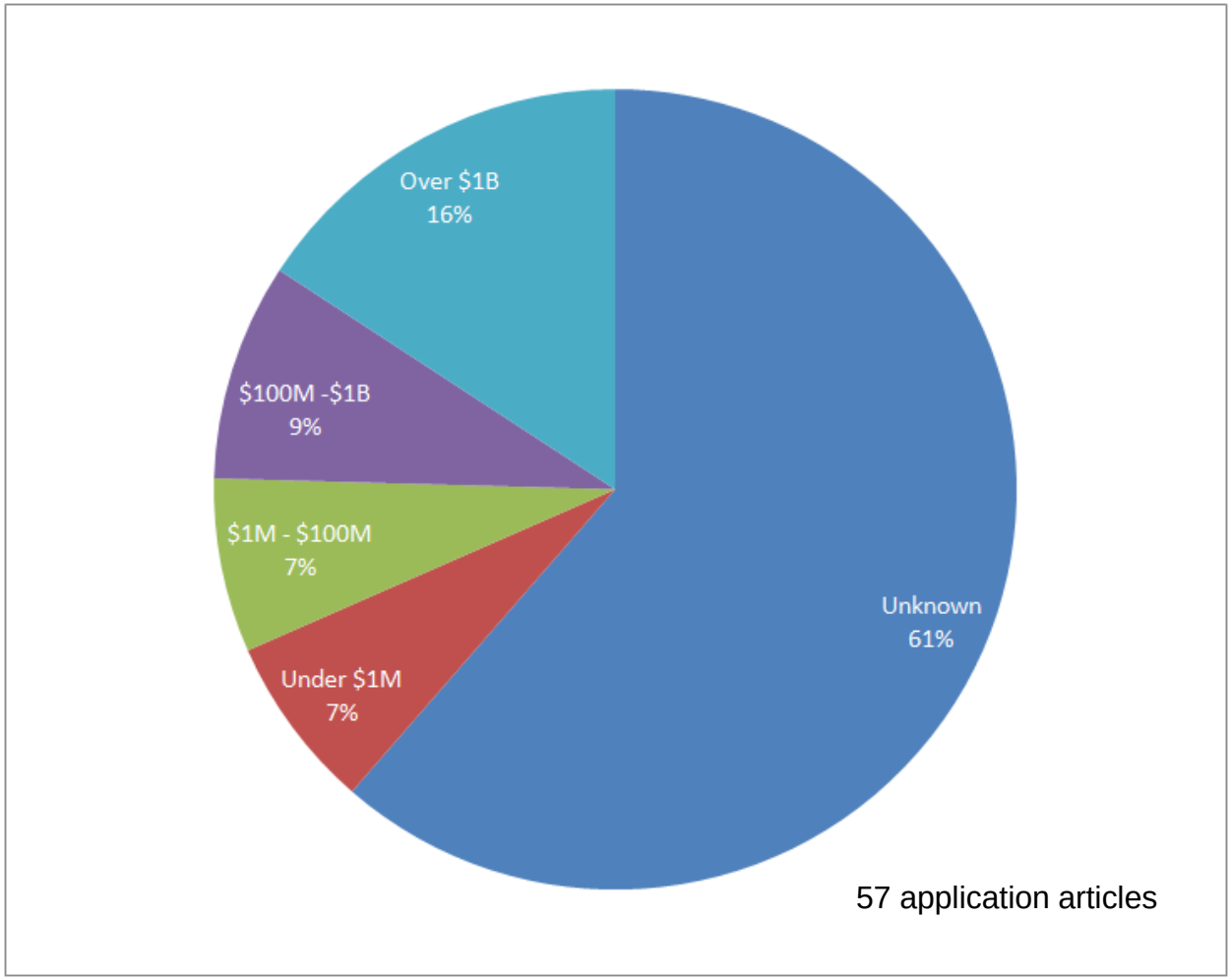
Application Clients



57 application articles

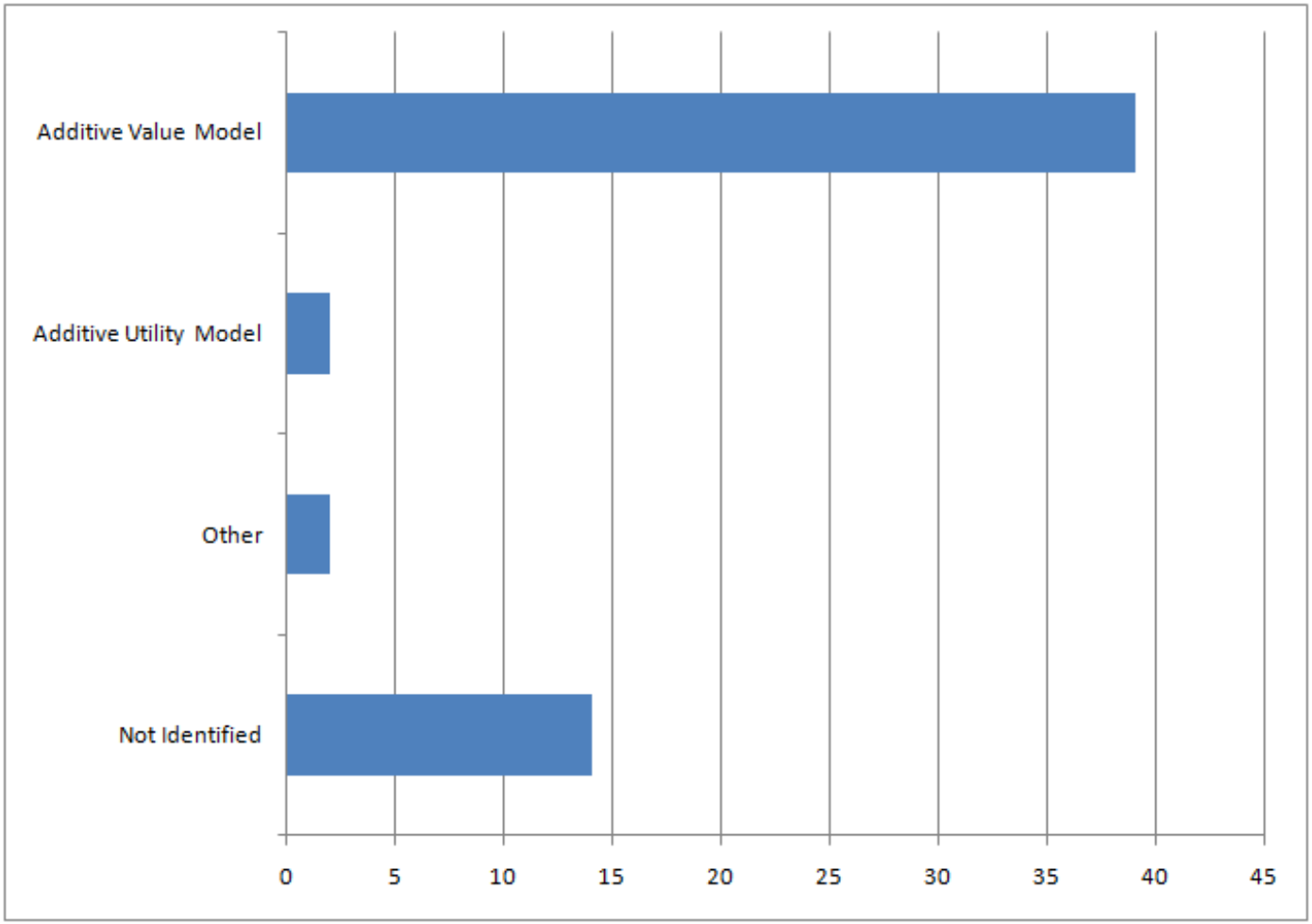
- Largest % of clients in the published articles are government/national policy and military leaders.

Applications – Size of the Decision Space



- Over 60% of the published application articles do not specify the dollar amount of the decision space.
- 7 of the 57 (16%) application articles involved decisions over $1 billion.

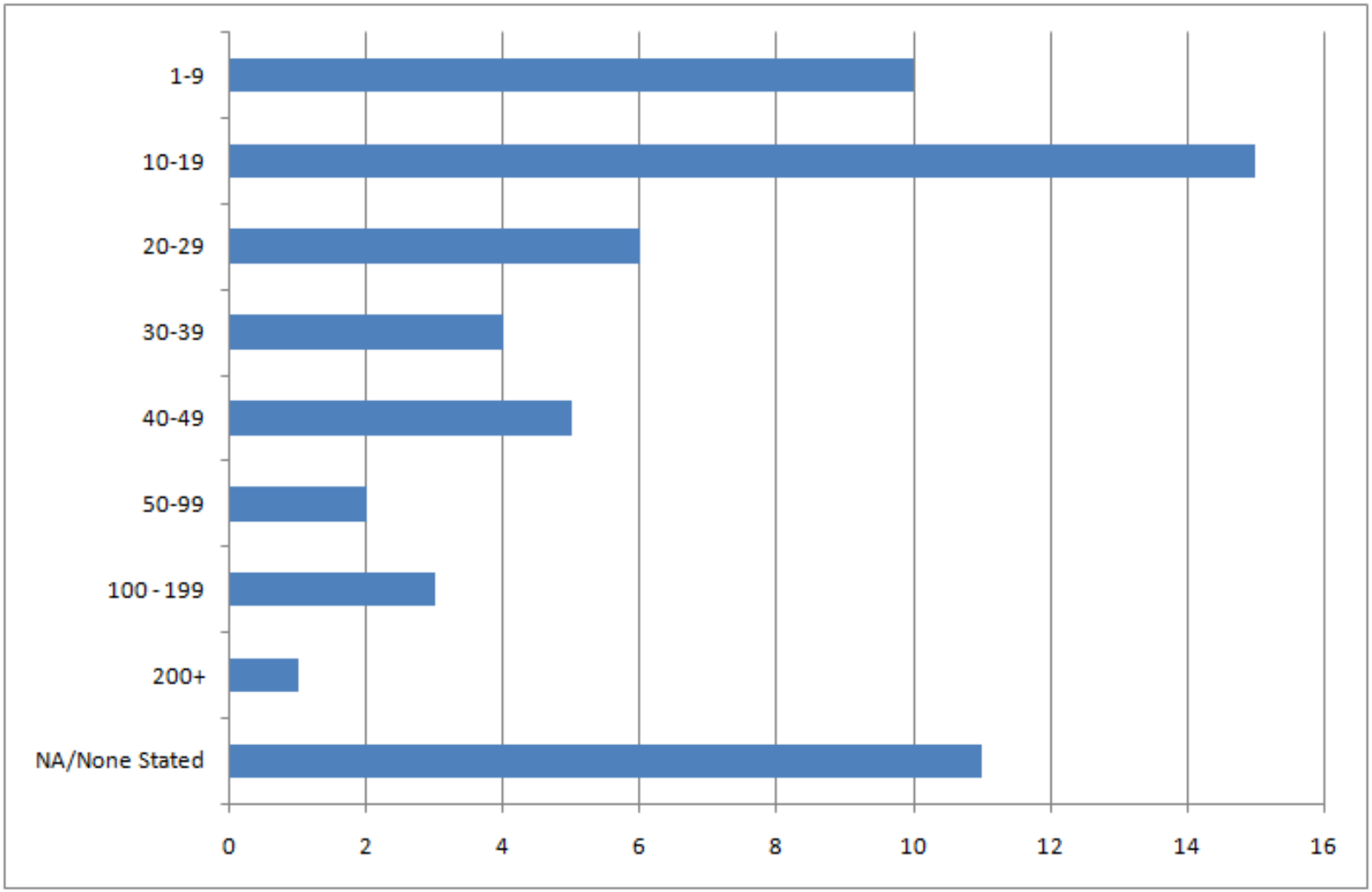
Applications – Mathematical Model Used



57 application articles

- At least 68% of the published application articles use the additive value model.
- Surprising number of papers did not identify the type of mathematical model used.

Number of Value Measures Used

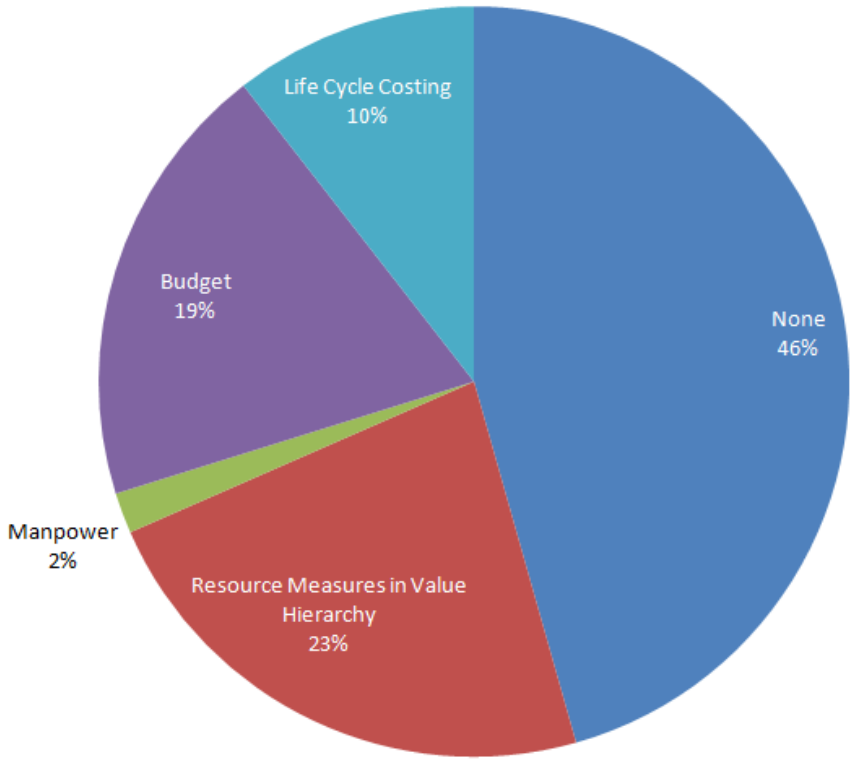


46 application articles with value measures

11 application articles with no identified measures

- Range of measures were from 2 to 256.
- Average was 35, Median was 17.
- 67% are less than 30 value measures.

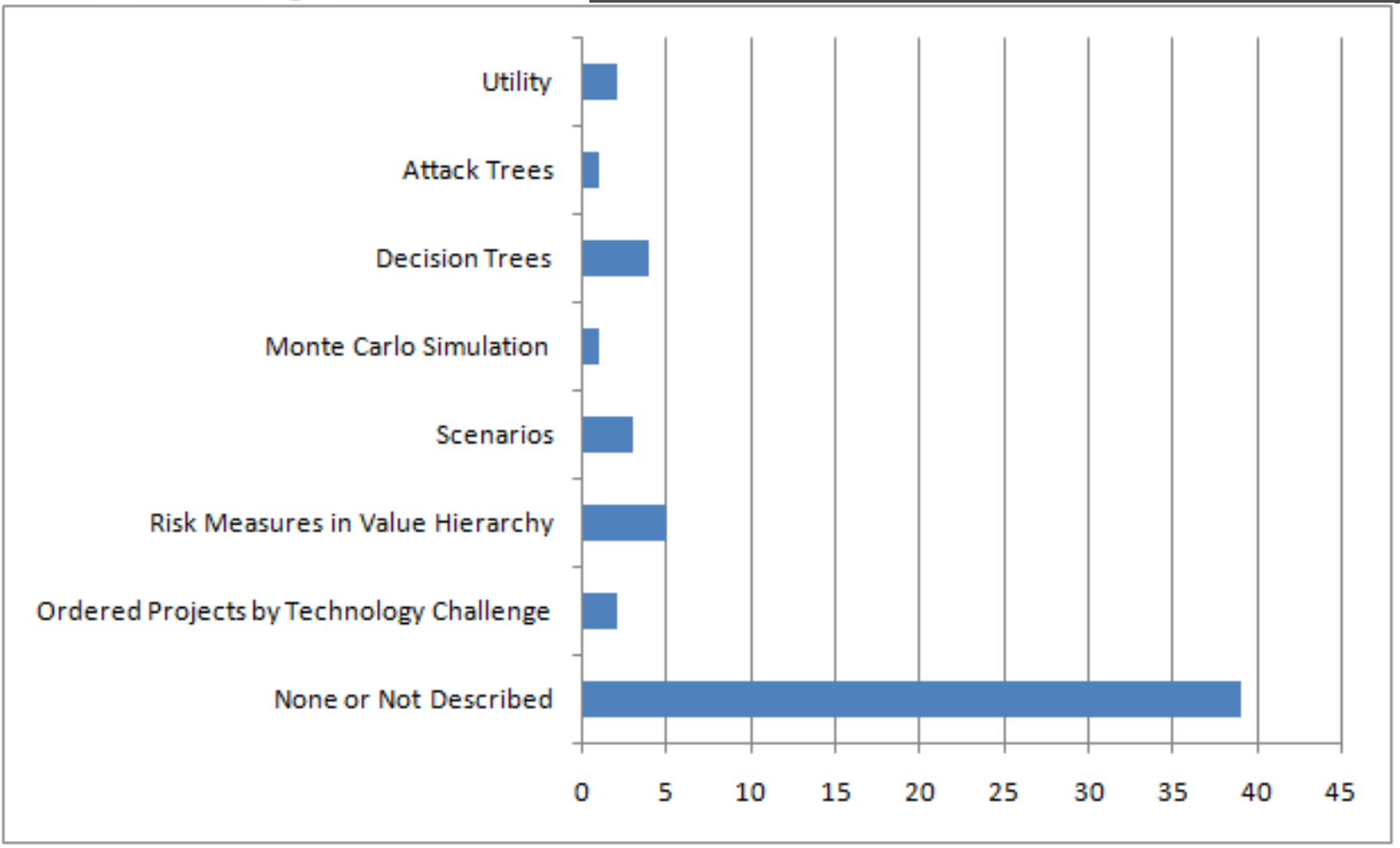
Applications – Resource Modeling



57 application articles

- Resources were not modeled in 46% of the published application articles.
- 31% used resource modeling separate from the value hierarchy.
- 23% used resource measures in the value hierarchy.

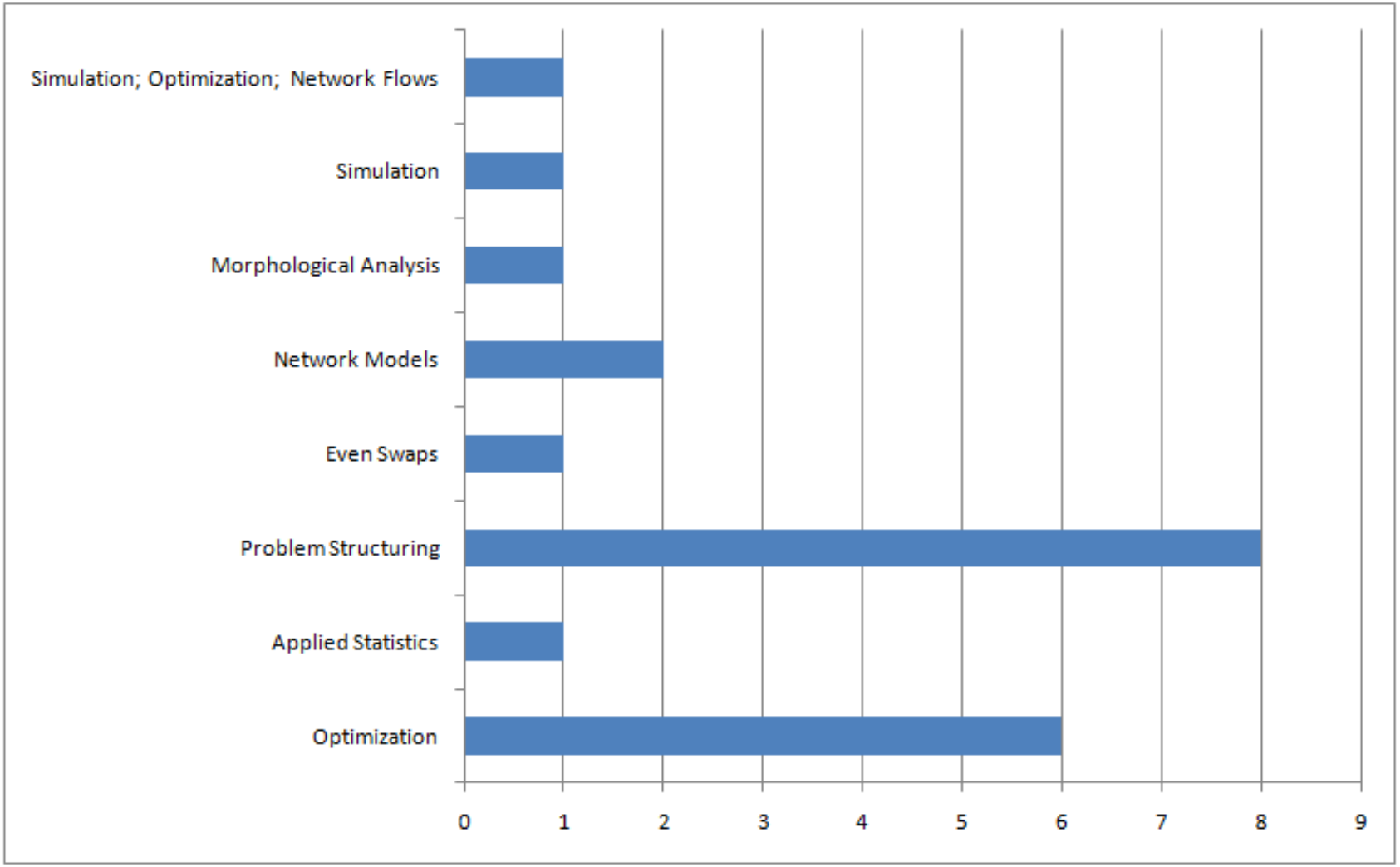
Applications – Uncertainty Modeling



57 application articles

- 68% of the published application articles did not describe or do uncertainty modeling.
- For the 32% that described uncertainty modeling, a variety of techniques were used to model uncertainty.

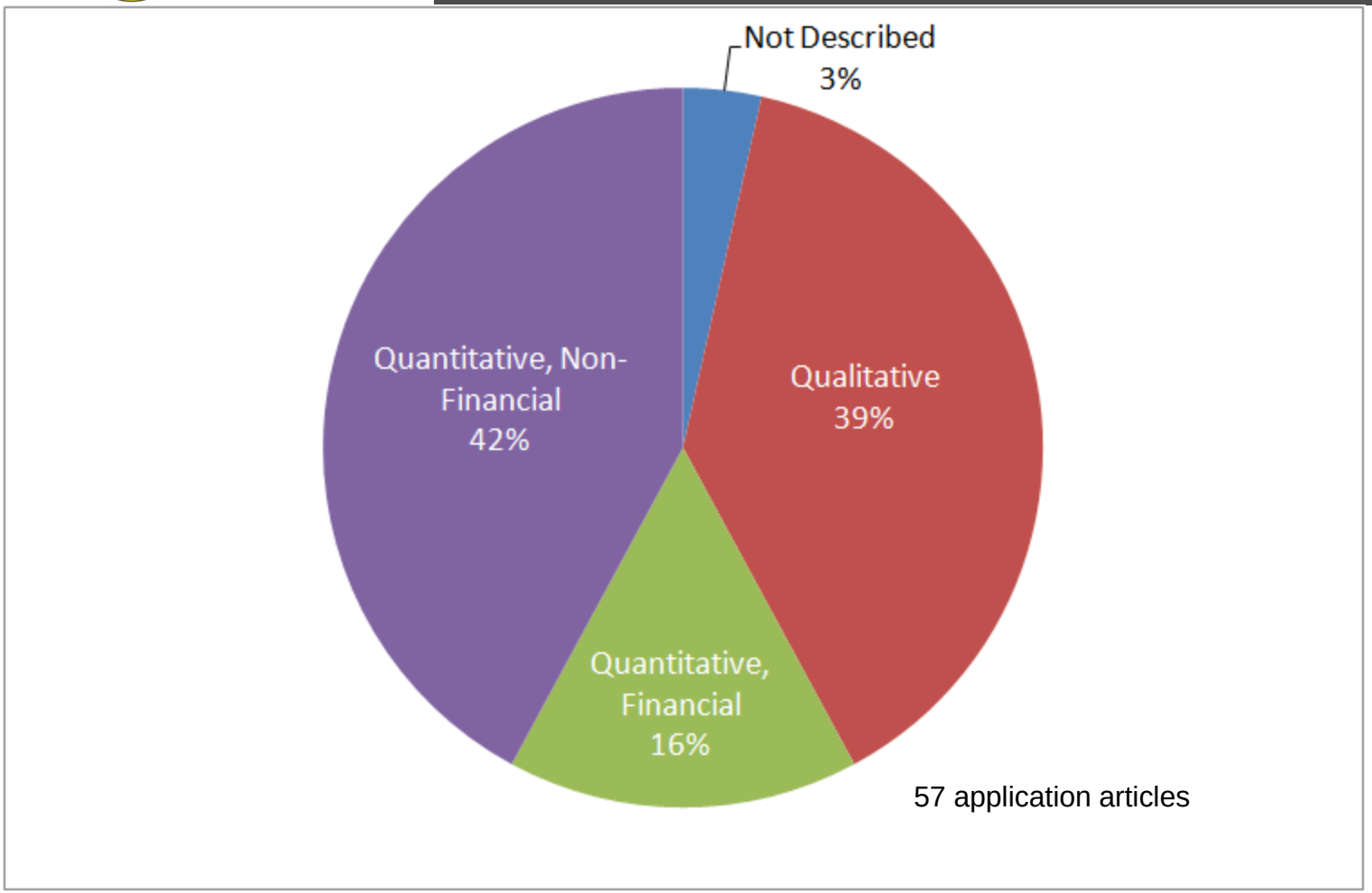
Other OR/MS Techniques



88 articles

- 21 of the 88 published papers used other OR/MS techniques.
- Problem structuring and optimizations were the most common techniques.

Applications – Impact



- 58% of the published applications described a quantitative impact.
- Only 16% identified a financial impact.

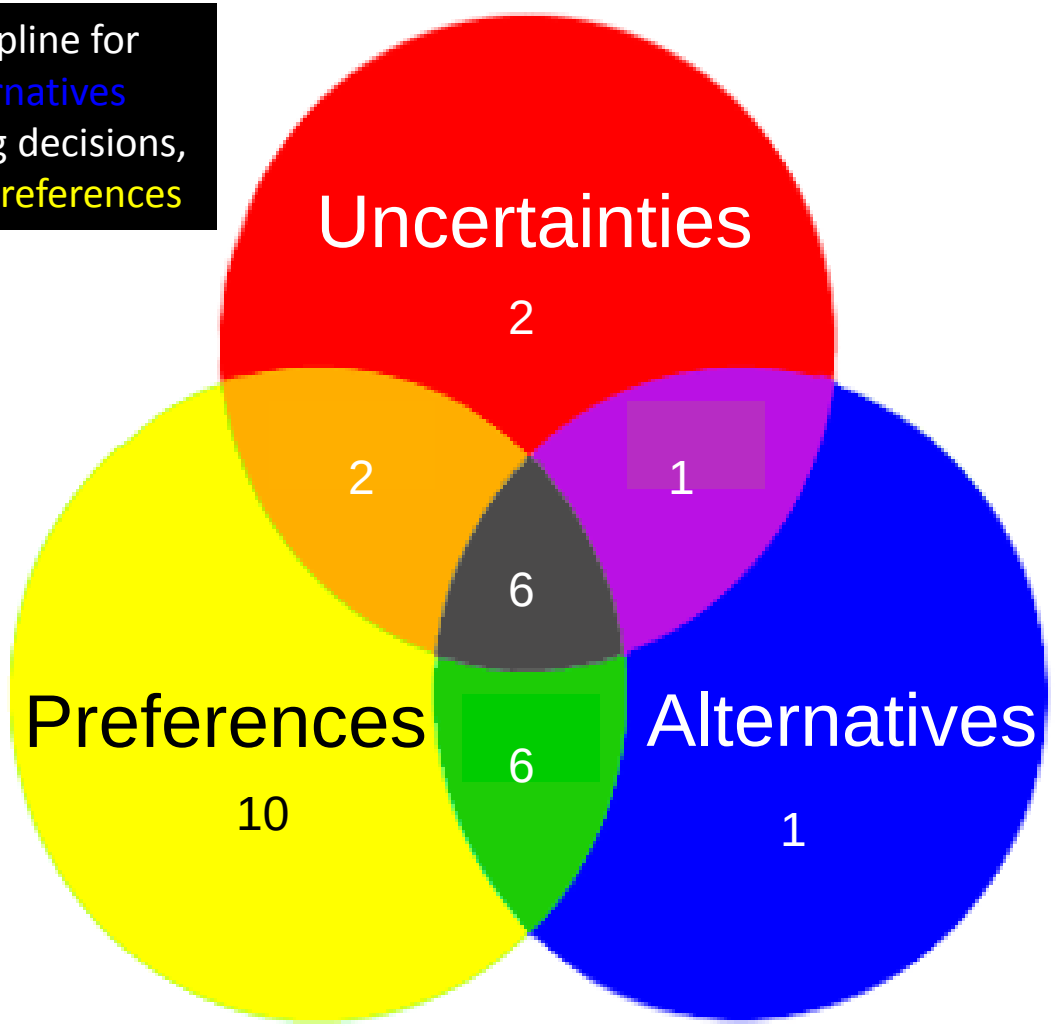
Applications Summary

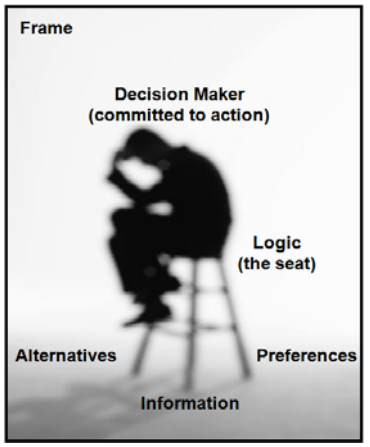
- Major benefits of VFT (data from 57 published applications).
  1. Identify and develop decision opportunities (45%).
  2. Start first with our values (46 out of 57 developed value measures).
  3. Use values to evaluate alternatives (65%).
  4. Use values to improve alternatives (32%).

- Ideas for improving VFT applications.
  1. Define the value of the decision space (preferably in $).
  2. Consider combining VFT with other OR/MS techniques.
  3. Use uncertainty modeling when appropriate.
  4. Use resource modeling.
  5. Quantify the impact (preferably in $).
  6. Use the Multiple Objective Decision Analysis model in the decision implementation process.

Research Contributions in DA Context

Decision Analysis: Discipline for evaluating complex alternatives systematically examining decisions, uncertain variables, & preferences



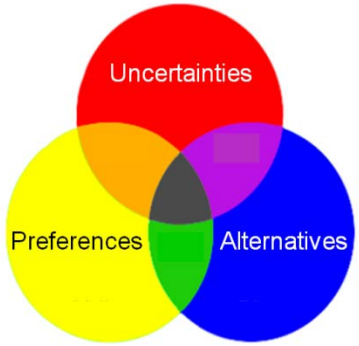


"A good decision is an action we take that is logically consistent with the alternatives we perceive, the information we have, and the preferences we feel."

- Ron Howard

24 of the 28 research contribution papers focused on preferences

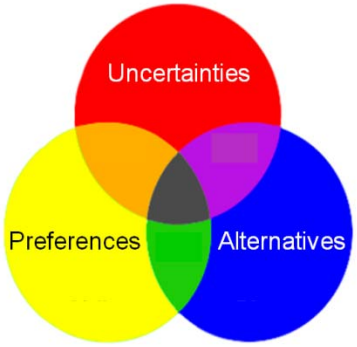
Research Contributions



Uncertainty Only

1. Constructed javelin diagrams for simple problems, discussed their properties, and illustrated their realistic application via a probabilistic sensitivity analysis of a seven-parameter decision analysis from the medical literature (Felli & Hazen, 2004).
2. Used risk penalty function to modify value model (Equipment Procurement, 2008).

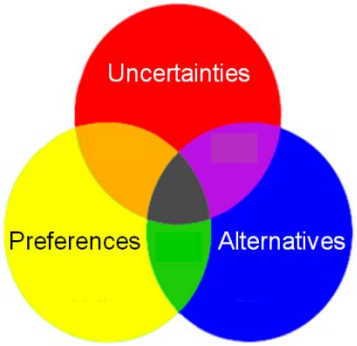
Research Contributions



Preferences Only

1. Used large scale diagramming for qualitative value model development (Air Force 2025, 1997).
2. Used parameterized value curves (S-Curves) and developed 2D value functions (National Reconnaissance Satellites, 2002).
3. Combined SWOT analysis and VFT to establish values and objectives (Tourism Management, 2003).
4. Developed anchor levels as a new tool for multiattribute utility theory. Anchor levels were applied to the measurement of quality of life during radiotherapy treatment, where there are complex interactions with what happens before and after. Using anchor levels, the measurements could be related exactly to the situation of the clients, thus simplifying the clients' cognitive burden (Wakker, Jansen, & Stiggelbout, 2004).
5. Developed attribute dominance utility functions to permit assessing multiattribute utility functions using common techniques of joint probability assessment such as marginal-conditional assessments and the method of copulas (Abbas & Howard 2005).
6. Used even swaps process, but in parallel, the evolution of the preferences of the decision maker is modeled with preference programming. With this model, we provided information to help identify practically dominated alternatives, and to find applicable candidate attributes for the next even swap (Mustajoki & Hämäläinen 2005).
7. Examined of the ability of VFT to facilitate more consensus oriented decisions for groups of stakeholders with conflicting preferences (River Rehabilitation, 2005).
8. Developed new swing technique called the Swing Weight Matrix (Army BRAC 2005, 2006).
9. Used Soft Systems Methodology (i.e. system thinking techniques) and VFT to elicit and structure objectives for evaluating energy efficiency initiatives (Energy Efficiency, 2009).
10. Explored ways of stimulating a more comprehensive set of objectives by presenting three experiments: the provision of sample objectives, organization of objectives by category, and direct challenges to do better, with or without a warning that important objectives are missing. The use of category names and direct challenges with a warning both led to improvements in the quantity of objectives generated without impacting their quality; other interventions yielded less improvement (Bond, Carlson, & Keeney, 2010).

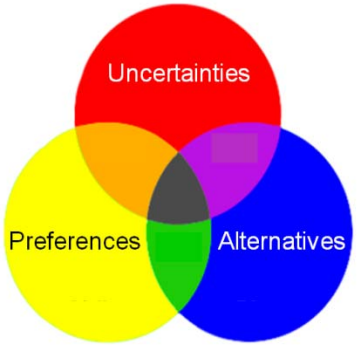
Research Contributions



Alternatives Only

1. Used cut sets in network modeling to identify alternatives (Network Disruption Modeling Tool, 2002).

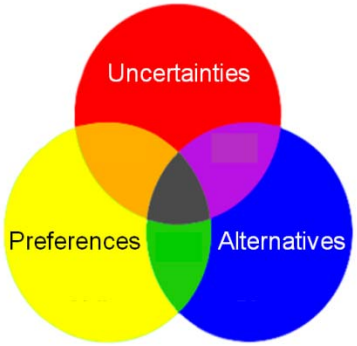
Research Contributions



Uncertainty and Preferences

1. Used alternate futures and large scale affinity diagramming for qualitative value modeling (Air Force 2025,1997).
2. Combined MODA and Monte Carlo simulation to perform Multiple Perspective Portfolio Analysis (National Reconnaissance Office R&D Portfolio Analysis, 2001).

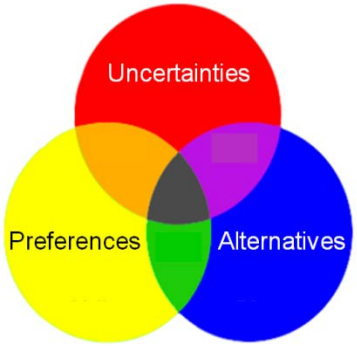
Research Contributions



Preferences and Alternatives

1. Advocates creating policy alternatives using stakeholder values (Gregory and Keeney, 1994).
2. Combined problem structuring methods and MODA. Developed strategic options using the COPE software for cognitive mapping and applied multiple criteria evaluation based on a multi-attribute value function with V.I.S.A. software (Hospital Supply Chain,1997).
3. Used MODA and network models to develop incremental iterative network upgrades (C4 Networks, 1999).
4. Advocates a dynamic approach alternating between criteria and alternatives to both better understand preferences and add new alternatives (Corner, Buchanan, & Henig, 2001).
5. Designed economically efficient financial loan packages for consumers and businesses (Financial Products, 2005).
6. VFT has significant benefits to identify and explore a large potential value space. Once the alternatives are finalized, there may be common value and unattained value. Decision-Focused Transformation preserves the original rank order of the alternatives and highlights the decision-relevant differences between alternatives (Dees, Dabkowski, & Parnell, 2010).

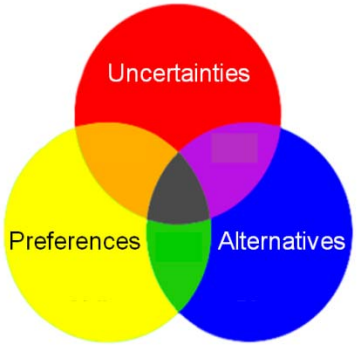
Research Contributions



Uncertainties and Alternatives

1. Focused on improving time-critical decision making in life-threatening situations. It contains two phases: The first identifies various decision-making situations in the organization and their classification according to the extent (severity) of time criticality in making and implementing the decision. This classification determines the necessary decision making and implementation procedures, whether they are cognitive or not. The second deals with the relevant components for improving the quality of the decision making (Time-Critical Decision Making, 2008).

Research Contributions



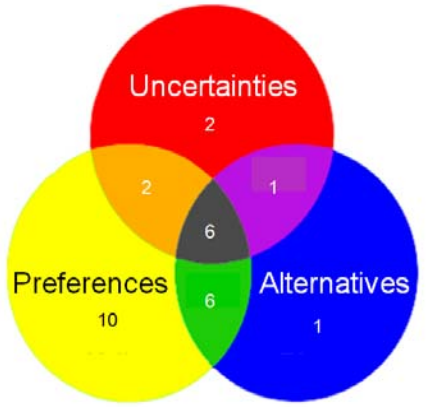
Intersection of Uncertainties, Preferences, and Alternatives

1. Identified need for techniques to help the decision maker envision the consequences of choice and incorporate values in the modeling process (Personal Decisions, 1999).
2. Combined VFT and Monte Carlo simulation to perform Multiple Perspective Portfolio Analysis (Air Force Research Laboratory Space Technology Portfolio Analysis, 2004).
3. Identified need for best practices and bias-resistant analysis procedures. In most application papers, there are no reports on the verification or testing of the procedures used (Hämäläinen, 2004).
4. Used a unique combination of risk analysis, decision analysis, and optimization to assess the information assurance risk for networks and develop risk management options (Mission Oriented Risk and Design Analysis of Critical Information Systems, 2005).
5. Advocates using VFT principles to develop risk management options after a probabilistic risk analysis (Paté-Cornell & Dillon-Merrill 2006).
6. Combined scenario analysis and MODA to illustrate how a diverse set of scenarios could be developed quickly, and to investigate how regret could be used to facilitate comparison of options. (Food security in Trinidad and Tobago, 2010).

Research Summary

- Major research findings.
  - 24 of the 28 papers focused on preferences.
  - 6 papers combined problem structuring techniques (SWOT, System Thinking, Scenario Analysis, Even Swaps, Cognitive Mapping) with VFT.
  - 7 papers used uncertainty techniques (Javelin Diagrams, Risk Penalty Functions, Scenario Analysis, Monte Carlo Simulation, Risk Analysis) with VFT.
  - 6 papers used alternative generation techniques (Stakeholder Values, Cognitive Mapping, Scenario Analysis, Network Models, Optimization) with VFT.

- Ideas for future VFT research.
  - Problem structuring techniques and value models.
  - Uncertainty analysis with VFT.
  - More systematic alternative generation techniques.
  - Consider combining VFT with other OR/MS techniques.
  - Use of VFT with portfolio decision making.



Conclusion

- Identified 88 significant VFT articles in 29 journals.
  - Growing number of international articles.
  - 41% of the VFT articles were written by authors outside the U.S.
- VFT has been used in a diverse set of problem domains.
  - Only 9% of the problem domains are corporate.
  - Largest % of clients are government/national policy and military leaders.
  - 45% of the decision articles used VFT to analyze decision opportunities.
  - 16% application articles involved decisions over $1 billion.
  - Over 60% of the articles do **not** specify the dollar amount of the decision space.
  - 58% described a quantitative impact (42% non-financial and 16% financial).
- VFT is used with other techniques.
  - For the 32% that described uncertainty modeling, a variety of techniques were used to model uncertainty.
  - Resources were modeled in 54% of the application articles.
  - About 25% used other OR/MS techniques.
- VFT research contributions.
  - 24 of the 28 papers focused on preferences.

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