

Abstract

The Delphi methodology can be a practical and valuable tool for cost estimators. This paper explores its proper implementation based on current research to include group selection, question formulation, statistical analysis, and the survey process. Special attention is paid to tailoring the Delphi method to cost estimating applications. A case study is presented for example purposes. The history of the Delphi method as well as modifications to the traditional Delphi method are also presented.

BCF solutions

Delphi Methodology for Cost Estimating Industry

Presented by: Cole Kupec



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Presentation Overview

- **Background on the Delphi Methodology**

- **Implementing the Delphi Methodology**
 - **When to choose Delphi**
 - **Objectives**
 - **Design**

- **Notional Example**

Delphi Methodology Background

- The Delphi method was developed by Norman Dalkey and others at the RAND Corporation. The method was originally developed in the 1950s to obtain the consensus of a group of experts on the viewpoint of a Soviet strategic planner
- A Delphi study is a multi-round surveying process to seek out information to build (which may build) a consensus
- Can be called methodology, technique, or approach

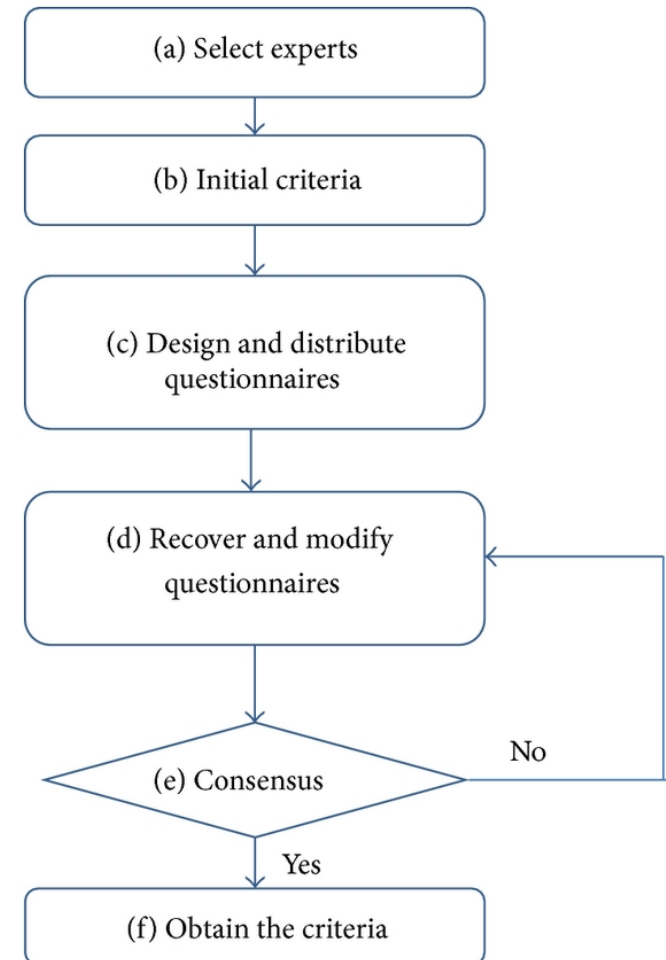
1. Group of experts, make independent individual estimates
2. Estimates are used to compute group mean
3. Group mean is presented to the group
4. Group once again makes individual estimates
5. Mean is again found for individual estimates
6. If new mean is different from previous, then repeat step four
7. Otherwise $\hat{E} = \text{Mean of final round of estimates}$

Delphi Methodology Overview

□ Four features are necessary for a procedure to be defined as a “Delphi”:

- 1) Anonymity
- 2) Iteration
- 3) Controlled feedback
- 4) The statistical aggregation of group response

□ There are a number of ways that these procedures can be applied



What is the Delphi Methodology?

- Systematically explore the judgment of experts
- Minimizes direct confrontation
- Exploratory in nature
- Useful when addressing interdisciplinary fields
- Appropriate when experts that are geographically spread out

Delphi Panel and Sample Size

- Study relies on the qualifications of the experts
- 10-15 individuals is a small sample size for a Delphi study, but it can still get reasonable results
- Other research suggests that the Delphi method gets the best results with 15-20 experts on the panel. This is because categorizing the volume of items that respondents generate can be difficult with larger groups

Delphi Methodology Objectives

- Delphi method can be used for these objectives:
 - 1) To determine or develop a range of possible alternatives
 - 2) To explore or expose underlying assumptions or information leading to different judgments
 - 3) To seek out information which may generate a consensus on the part of the respondent group
 - 4) To correlate informed judgments on a topic spanning a wide range of disciplines
 - 5) To educate the respondent group as to the diverse and interrelated aspects of the topic

Delphi Methodology Applied to Cost Estimating

- Finding cost drivers: FTE, SLOC, Travel, etc.
- Coming up with the “best” of all the good ideas
- Usually not a quick process
 - ▣ Requires planning
 - ▣ Gathering SMEs
- When could it be used:
 - ▣ Different opinions from various SMEs
 - ▣ Multi-disciplinary problems
 - ▣ Geographically dispersed SMEs
 - ▣ Cost data not accessible
 - ▣ Need a cross check
 - ▣ Results given more credence than estimator working inside their “bubble”

It is another tool in the operations researcher's tool box!

Notional Example: Building the XYZ Machine

- Program management needs to understand scope and develop a cost estimate for a cutting edge machine requiring a multi-disciplinary team spread out across the continental United States
- Due to an absence of empirical data the cost estimator has chosen to use engineering judgment and expert opinion with the Delphi methodology

Steps in the Delphi Study

- Find participants and panel
- Round 1- Ask the question
- Round 2- Ask relevance of response
- Round 3- Ask to build consensus (repeat as needed)
- Round 4- Ask which is necessary, supplemental, or neither
- Findings
- Recommendations

Round 1

- The researcher posed an open-ended question for the participants to consider:

Using your professional judgment please describe the total scope required to develop the XYZ machine? Please include specifics such as SLOC, function, weight, anticipated development and deployment needs, maintenance considerations, etc. Please be specific and explain in as much detail as is required.

- Responses were gathered and consolidated by independent panel of three subject matter experts based on key words and criteria. This aggregated data was used to create the questionnaire for the following rounds.

Round 2

- The content from Round 1 was used to generate a Likert-type scale survey for Round 2 using a panel of three subject matter experts:

Survey Question Number	Variable					
1	FTE	5	10	15	20	25
2	ESLOC Count	50,000	100,000	150,000	200,000	250,000
3	Development Schedule	6 Months	12 Months	18 Months	24 Months	30 Months
4	Technical Risk	(1) No Risk	(2) Limited Risk	(3) Moderate Risk	(4) Significant Risk	(5) Most Risk

- From these data the mean score, median, standard deviation, and interquartile range for each question was computed.
- Round 2 is where agreements and disagreements between the panelists begin to be identified. Any scope with a large interquartile range would indicate a disagreement between panelists on their rating of the scope.

Round 2 Results

- 1) FTE Range: 5 - 25
- 2) ESLOC Range: 50,000 – 250,000
- 3) Schedule Range: 6 Months – 30 Months
- 4) Technical Risk Range: (1) No Risk – (5) Most Risk

**Large Interquartile
Range (IQR) means
dispersion**

Survey Question Number	Variable	Mean	Median	Standard Deviation	IQR
1	FTE	19.55	20	3.35	2.5
2	ESLOC Count	159,000	150,000	36,000	50,000
3	Development Schedule (Months)	22.92	24	5.64	9
4	Technical Risk	3.82	4	1.11	2

Ordinal Data Relevance

Rank order not important because they should be addressed individually

Round 3

- Scope from Round 2 were presented in the same order with the mean score, median, standard deviation, and interquartile range for each of the variables of scope.
- The mean score, median, standard deviation, and interquartile range for each variable of scope were computed again. The coefficient of variation was also calculated. If the coefficient of variation is between 0.00 and 0.50, there is a strong consensus for each of the knowledge and abilities in the research question. The rationales for answers lying outside the interquartile range were compiled as well.
- The panelists were given two weeks to complete Round 3.
- Since consensus was reached, if there was still disagreement, then the process repeats until a consensus is reached.

Round 3 Results

- 1) FTE Range: 5 - 25
- 2) ESLOC Range: 50,000 – 250,000
- 3) Schedule Range: 6 Months – 30 Months
- 4) Technical Risk Range: (1) No Risk – (5) Most Risk

Round 3						
Survey Question Number	Variable	Mean	Median	Standard Deviation	IQR	CV
1	FTE	19.15	20	3.45	0	0.18
2	ESLOC Count	150,000	150,000	24,500	25,000	0.24
3	Development Schedule (Months)	21.48	24	4.26	6	0.21
4	Technical Risk	4.08	4	0.49	0	0.12

Delta Between Round 2 and Round 3				
Survey Question Number	Variable	Mean	Median	Standard Deviation
1	FTE	-0.4	0	0.1
2	ESLOC Count	-9000	0	-11500
3	Development Schedule (Months)	-1.44	0	-1.38
4	Technical Risk	0.26	0	-0.62

Convergence !

Round 4 (Optional)

- Not found in this example, however, where applicable ask if a scope considerations is truly necessary, supplemental, or neither to the successful scope consideration of the XYZ machine:
- **Necessary** scope considerations are of core importance and needed for the XYZ machine to be considered adequate. Necessary scope make up the body of project critical scope.
- **Supplemental** scope considerations are of some importance and may not be needed for the XYZ machine to be considered adequate. Supplemental scope make up the “nice to haves” of project scope.
- Or **Neither** necessary or supplemental

Findings

- Key findings for the XYZ machine include:
 - ▣ FTE mean of 19.15 and median of 20
 - ▣ ESLOC count mean and median of 150,000
 - ▣ Schedule mean of 21.48 and a median of 24, so the project will be likely be completed in the 4th quarter of the second year
 - ▣ Technical risk parameters are a significant risk (4), and should be a strong consideration when modeling cost

Summary

- Coming up with the “best” of all the good ideas
- Systematically explore the judgment of experts
- Minimizes direct confrontation
- Exploratory in nature
- The Delphi methodology is another tool in the operations researcher’s tool box!

Questions?

Reference materials and links available upon request

Please feel free to email me at:
cole.kupec.ctr@mda.mil

Thank you for your time!