Expert judgement in resource forecasting – the use of the Delphi method to achieve group consensus

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Abstract. Expert judgement is used in a novel resource forecasting method to build models that forecast resource requirements. In this study, a collaborative decision-making process is deployed to ensure user acceptance in an empirical setting with limited legacy data for model validation. The Delphi method allowed facilitating this process and to achieve group consensus during estimate collection. With action research, Delphi parameters are adjusted in three concurrent case studies involving different expert groups. This study shows that Delphi is a useful and valid approach to provide acceptable degree validation for quantitative empirical expert models if only limited legacy data is available for model validation.

Keywords: expert judgement, group consensus, resource forecasting, collaborative decision-making process, Delphi method

1 Introduction

Expert judgement is deployed in estimation-based resource forecasting methods. It can be subjective, prone to bias and errors, lacking transparency, difficult to retain in house as well as to modify and reuse [1] and [2].

A novel resource forecasting method [3], not only addresses these commonly associated limitations, but offers an expedient technique to build expert models through the efficient and structured collection of expert estimations by analyzing the patterns between expert judgements and carefully structured scenarios. Individual models are built based on participant estimates. In applications to date, a small amount of legacy project data has been available to validate and select the most suitable model thereby encouraging confidence in model results.

In this study, expert models are built with the method described in [3] but in an empirical setting with limited legacy data for model validation. Consequently, the aim of this study is to ensure that the developed models are accepted and perceive as valid by users. In order to achieve that, we first identify a method in literature that will allow us to use the collective knowledge of experts as one group estimate. Second, we will apply that method in an empirical setting with limited legacy data and explore if the resulting approach provides acceptable degree validation for quantitative empirical expert models.

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2 Literature review

The literature review is split in two parts: first, the most suitable method is selected to address the research problem at hand. Given the research context, the fields of group decision processes and demand forecasting are reviewed and the selected method is introduced.

2.1. Selecting a method to address the research problem

Techniques and methods in group decision processes and demand forecasting are reviewed in order to identify a suitable method to address the research problem in this study and with respect to our objective to achieve expert group consensus.

In demand forecasting, it is commonly distinguished between 'hard' methods that are quantitative, i.e. numerical or empirical, and 'soft' methods which focus on qualitative parameters like judgments and tacit knowledge. Delphi, Focus Groups and Estimation-Talk-Estimation are examples of the latter for which [4] emphasize a poor support of computer-based tools because a large quality of data cannot be integrated which compromises their scalability. To reduce the limitations of qualitative techniques, the 'Hybrid Delphi' is a methodology that considered elements of Focus Groups, Delphi and Nominal Group Technique (NGT) [5].

In terms of expert group consensus, methods can be 'informal', such as Unstructured Group Discussion, Focus Groups or Interviews, or 'formal', such as Delphi, NGT and Consensus Development Conference [6].

The novel forecasting method in this study already combines elements of judgement and data-based forecasting methods [3]. Thus, a suitable method in our case should rather comply with the criteria set out in table 1 than being a 'hybrid' itself, see for example [5]. Thus, the three short-listed methods from the above review are assessed against these criteria.

Table 1. Assessment of most suitable method based on selection criteria
Source: authors defined criteria and assessed methods under consideration of [4], [6], [7]

Criteria	Focus groups	Delphi	Nominal group technique
Accommodates qualitative and quantitative elements	No, qualitative only	Yes	Yes
Applicable in situations with limited legacy data	Unknown	Yes	Unknown
Formal and structured method to achieve group consensus	No	Yes	Yes

The assessment against study criteria clearly rules out Focus Groups. In terms of NGT, its applicability in situations with limited data is not known from the reviewed literature. So it could be an option, however as a creative technique, it is to generate and order ideas or to identify factors of a problem [5] which is both not the application in this study. Thus, Delphi was selected as the most suitable method in light of the study criteria. The use of Delphi is supported by [7], emphasizing the criticality of expert judgement in situations when other sources, for example legacy data, are unavailable.

2.2. The Delphi method

This part introduces the selected Delphi method which will be used in the study to addresses the research problem and achieve the aim of the study. The Delphi method has been used in applied research to develop, identify, forecast and validate [8]. It is an established group consensus method to aid judgement under uncertainty and makes best use of available information rather than creating new knowledge [9] and [10].

Delphi was first applied in 1956 at the Rand Corporation with the objective to select an optimal industrial target in the United States, thereby taking on the viewpoint of soviet strategic planners [11]. Because of this military context during the cold war, the paper with an explanation of the deployed Delphi technique and the underlying approach was published 10 years later. In this context, [11] asked experts for a numerical estimate, the number of bombs required to destroy certain targets in the country. The underlying assumption was that even though initial estimates might vary and diverge, they will converge with increasing numbers of iterations.

Another aspect was the importance of controlled interactions. They allowed for the systematic exploration of the factors that turned out to have an influence on their estimates. By allowing participants to correct their estimates in each round, terminal disagreement was decreased. Also, respondents were asked to provide reasoning to their estimate which clarified underlying assumptions that guided their estimate and enabled the provision of feedback to other respondents [11].

Nowadays, Delphi is a mature and very research method that is used in a variety of disciplines and industry sectors including health care, defense, business, education, information technology, transportation and engineering [8]. Despite various methodological variations, the classical Delphi method consists of questionnaires for experts, who fill them in anonymously, receive controlled feedback to revise estimates between rounds. The final individual estimates are equally weighted to produce a statistical group response [12]. These key parameters are essential in our research approach which is discussed next.

3 Research Approach

For the first time, the Delphi method is deployed together with the novel resource forecasting method [3]. This is to ensure user acceptance and validity in an instance with limited legacy data for model validation.

Three engineering expert groups contributed to the creation of a resource forecasting tool at an automotive company in the United Kingdom. The forecasting tool consisted of expert models that forecast resource requirements. Each expert group was one case which results in a total of three case studies in this research. The expert groups differed in size: case study A consisted of 8, case study B of 2 and cast study C of 3 participants. Action research was used to adjust Delphi parameters across the concurrent cases. Data were collected by means of observation in 2015 and early 2016.

The Delphi method facilitated a collaborative decision-making process to derive group consensus on expert judgements. The resulting group estimates were used to build the models that constituted the resource forecasting tool.

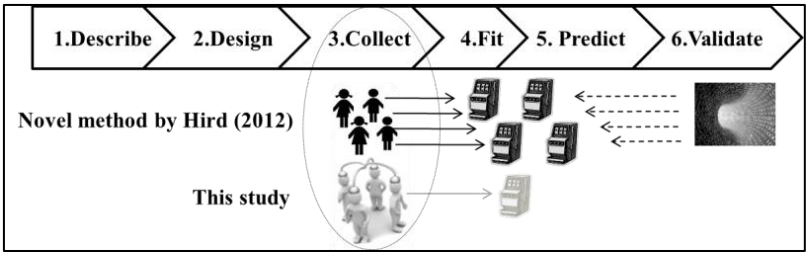

Fig.1 Collaborative decision-making for one group estimate instead of collecting individual estimates

The above figure shows that the focus of this study was on estimate collection. It is in this process step that the study differed from the proposed novel forecasting method [3]. Instead of several individual estimates, the collective knowledge of engineering subject matter experts resulted in one group estimate. This had an impact on the following procedural steps: rather than building several individual models that are validated with historical data [3], one model was built with each final group estimate.

Achieving group consensus is a prerequisite to derive one final group estimate from the collective knowledge of engineering subject matter experts. This required a collaborative decision-making process which was facilitated by the Delphi method. However, across the three cases, adaptations to Delphi parameters were made which resulted in different degrees of the classical Delphi approach and other findings which are discussed in the next part.

4 Findings and discussion

During model development, the four parameters of the 'classical Delphi' [12] were adapted to suit the requirements of each case. We found also that four other parameters were important: note taking of assumptions during estimations, whether the full scope of estimation parameter was known at the start, the availability of experts and if the group worked under time pressure. The findings for each case are summarized in the next table.

Table 2. Overview of findings from three case studies
Source: authors under consideration of [12] for Delphi parameters

Parameter	**Case study A** #8 experts	**Case study B** #2 experts	**Case study C** #3 experts
1. Degree of classical Delphi	High	Low	Medium
1.1.Anonymity	*Yes*	*No*	*No*
1.2. Iterative rounds of individual estimation	*Yes*	*Never*	*Sometimes*
1.3. Controlled individual feedback	*Yes*	*Never*	*Sometimes*
1.4. Final group estimate equally weighted	*Yes*	*Yes*	*Yes*
2. Note taking of assumptions	Sometimes	Never	Always
3. Full scope of estimation known at start	No	No	Yes
4. Expert availability	Good	Poor	Fair
5.Time pressure	Low	Medium	High

In terms of the Delphi parameters, the only commonality across all three cases was that the final group estimate was computed by equally weighting the final estimates of participants. Particularly in case study A, expert group judgement was derived by way of several rounds of individual estimations and feedback under anonymous conditions; unlike case study B and C in which participants preferred less formal means to make a group decision for an estimate. Following from that, case study A had a high degree of compliance with the classical Delphi parameters unlike cases B and C. In fact, participants in case studies B and C opted for group meetings to review surveys and estimated collectively through direct discussion and exchange of opinions. The subsequent weighting of their final estimates was thus more a symbolic act than a formal procedure.

We found that ‘expert availability’ and ‘time pressure’ were two parameters in favour of the group in case study A whereas both parameters compromised the use of Delphi in case studies B and C which resulted in a less formal use of its classical form. On that, we noted that group size played a role: the larger the group, the more there was a need for a formal process to take each individual expert opinion into account so as to derive consensus on one group estimate for each model.

Interesting was that participants in case study C, were keen to note down assumptions about their estimates. It is not a ‘classical’ Delphi parameter [12] and was not made use of in the other two case studies. Still, for the expert group in case study C, note taking was an important means to not only capture assumptions made for the group estimate, but also to acknowledge individual positions and viewpoints. This had a positive impact on the achievement of consensus in this group.

Apart from the use of Delphi, knowing the full scope of estimation at the start is a parameter that differed across cases. This is an aspect that could have been managed better in case A, in light of the low time pressure and good expert availability, and allowed the group in case C, which worked under high time pressure, not to waste time going back and scoping out the work again as in case studies A and B.

The novel resource forecasting method proved highly versatile and, when combined with Delphi, allowed us to build a forecasting tool which has shown promising results in first trials: resource forecasts were generated faster than through manual estimation and more consistent because regardless of who will use the tool, the same forecasts are generated. This consistency avoids bias and subjective opinions of individuals when asked to provide estimates. An additional aspect is that the models' algorithms allow insights on the drivers of resource effort which was previously intangible knowledge. In conclusion, we encourage the use of the novel resource forecasting method in light of its versatility and to deploy the Delphi method when group expert judgement, rather than individual estimates, is desired.

After the use of Delphi to derive expert group estimates, the fitting and predicting stages followed before model validation (see fig.1). In the latter phase, there was only limited historical data available but it turned out that engineering experts showed high levels of confidence in the models which were built with their collective knowledge. This manifested in keen interest by experts to use the presented forecasting tool prototype on first live projects. Thus, it can be concluded that the deployed procedure to build the empirical models was accepted and perceived as valid and sensible by users.

5 Conclusion

This study has shown that the Delphi method is a useful and valid approach to facilitate a collaborative decision-making process so as to achieve consensus in expert group judgements and build models that are accepted by experts. Delphi enabled the development of resource forecasting models with collective knowledge of experts in an empirical setting with limited legacy data.

The discussed findings in this study on the application of Delphi to achieve consensus and derive expert group estimates extend beyond the novel method's immediate managerial outcomes - the provision of expert models to forecast resource effort. In fact, they are of relevance to practitioners and researchers. For the former, it could guide workforce training, collective group decision-making in other areas and the management of project characteristics based on their importance as effort drivers. Also, the empirical insights from this paper can be of relevance to researchers who study the Delphi method, group dynamics, consensus building, knowledge management or expert judgement.

This was, to our knowledge, the first study in resource forecasting that investigated the use of the Delphi method to facilitate a collaborative decision-making process in order to achieve consensus in expert group judgements. While it yielded valuable insights, future research is needed to address the limitations of this study.

Timing was an aspect that had to be actively managed and resulted from the situation that, on the one hand, the study could only take place in a specific time frame while, on the other hand, experts were not always available when required in the process. It would be interesting to see future investigations with a view to the generation of results without time constraints.

In terms of sample size, we have presented the results of three case studies based on three expert groups that differed in size between 3 and 8 participants.

Since we found that group size plays a role regarding the need for formal procedures the larger the group is, future studies could explore if there is an ideal group size when using Delphi in this context.

Future studies could also collect data differently, for example by using surveys to assess participants' satisfaction with the procedure.

We agree with [5] that, for the use of Delphi, the computer-based tools for data collection, analysis and outcome visualisation are rather limited and we would be keen to see if proposed visual dashboards would improve the Delphi process particularly with a view to improving the provision of feedback to support participants' ability to revisit their estimates.

Another aspect that could be investigated is the adaptation of Delphi parameters without using action research. In this study, the cases ran concurrently at times and this approach provided us with flexibility to change parameters in accordance with the requirements and preferred mode of operation in the respective case. It would be interesting to assess the overall success when adhering strictly to a procedure, like the classical Delphi approach, without changing parameters.

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