A Review of the Expert Opinion Technique and Recommendations to Reduce its Bias

Information acquiring, gathering, analysing and using have dominated an important part in our life. Whether you want to decide the suitable clothes for the weather, to take an important decision in your organization or to represent data to a decision maker, you are definitely going to require information as an asset supporting such decisions. As an analyst, or specifically as a forecaster, you will need various sources of information depending on your approach and purpose. Considering a traditional classification of quantitative and qualitative analyses, experts' opinion usually plays a major role for the second one in addition to combined approaches of both. This white paper addresses the procedures carried out with the purpose of technology forecasting in order to gather and analyse information from knowledgeable people (here referred to as experts) about the technology context (technology delivery system), evolution and/or possible futures. The aim is to provide a list of recommendations and guidelines to reduce the biases resulting from these procedures of expert-opinion extraction. A focus field is spotted on the recommendations suitable for the techniques already in use by FORMAT researchers (interview technique and questionnaires) and on the Delphi technique for future consideration of running a Delphi survey in the FORMAT methodology as an auxiliary building block.

First, an attention is drawn to the topics previously discussed about the expert opinion in deliverable 2.5 of the FORMAT project [1]: "who are experts?", "when do we need experts?" and "what are the biases that are present in experts' opinion". This discussion shall be extended here to explain other sources of bias during the whole technique and to provide a step-by-step guide for designing and setting up an expert opinion technique in order to reduce the effect of these bias sources on technology forecasting. The paper highlights various techniques to gather information from experts and refers to the techniques used in the FORMAT methodology.

Some guidelines shall be explained about selection criteria of experts and the problems of extracting knowledge from experts. The bias from the optimal forecast is the main threat resulting from these problems. Therefore, in order to reduce experts' bias, the main part of the discussion will focus on the general recommendations and guidelines that could be taken into account before, during and after the design and carrying out of your expert-opinion technique.

1. Definitions and Assumptions

As mentioned in Deliverable 2.5 [1], experts are "people with information about the technology of interest to the forecaster". The expert-opinion technique simply assumes that some people have more knowledge than others about a certain topic; and if you collect this knowledge from a group of experts, the results will definitely exceed the outcomes collected from one expert [2]. The group of experts can provide technical, economic, social and/or environmental perspectives that could be difficult to reach by the forecasters on their own.

The expert opinion method is needed the most, when historical data are insufficient, modelling is difficult and/or a completely new product is forecasted. In most cases, it is applied when experts in the area under study can be defined and they are able to contribute.

Armstrong [8] defined a forecast bias as a systematic deviation from the optimal forecast which will occur in the future as forecasted. Such a deviation can be then well evaluated after the end of the forecasted time. This white paper assumes that, during the expert opinion elicitation, any reason that can lead to a deviation from the optimal forecast is a possible source of bias that is recommended to be eliminated, reduced or taken into account during the analysis and assessment of the forecast. These reasons and recommendations are reviewed from the referenced literature [1-13], clustered and represented in a step-by-step guide. Only the bias due to human interaction is considered in this review. Other sources of bias of expert opinion techniques

have been considered out of scope of this review: such as physical factors (room temperature, noise, etc.) and interaction between human and machine (hardware, software, etc.) during the task.

The first step of eliminating bias is to understand the sources of bias, which can be clustered into three categories:

- Bias due to the expert's background
- Bias due to the communication between experts
- Bias due to the communication between forecasters and experts

The sources of bias in the whole technique are shown in figure 1. Bias due to expert has been discussed in Deliverable 2.5 of FORMAT project [1] with reference to Goodwin and Wright [3] who have accounted for the causes of low predictability. Other sources of bias are discussed during the next chapters in this white paper.
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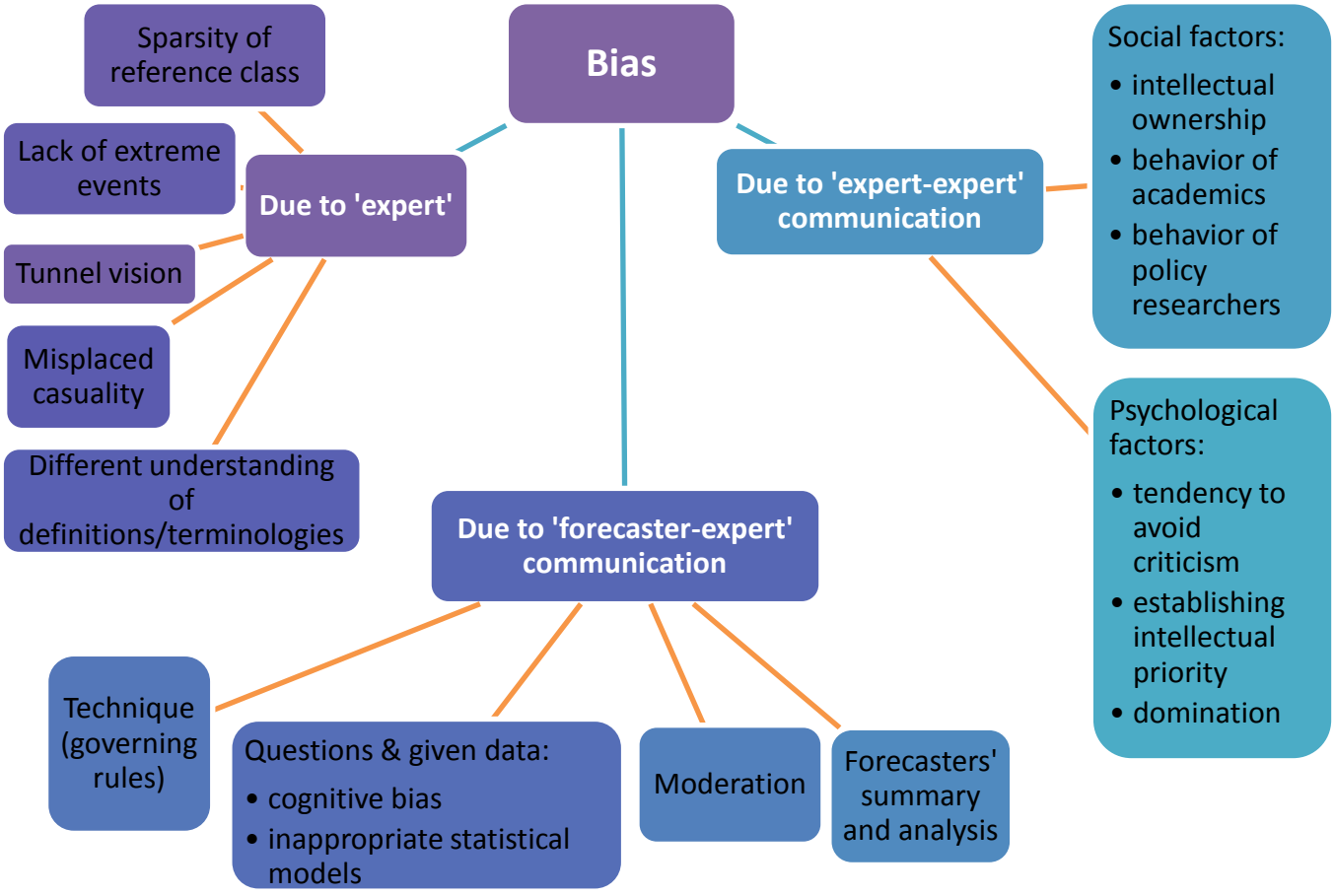


Figure 1: Various reasons of bias that can cause a forecast to deviate from the optimal results. The reasons are clustered under the various sources of bias due to: 'expert', 'forecaster-expert' communication and 'expert-expert' communication.

2. The design

2.1. Starting up the method: (Guidelines to choose experts)

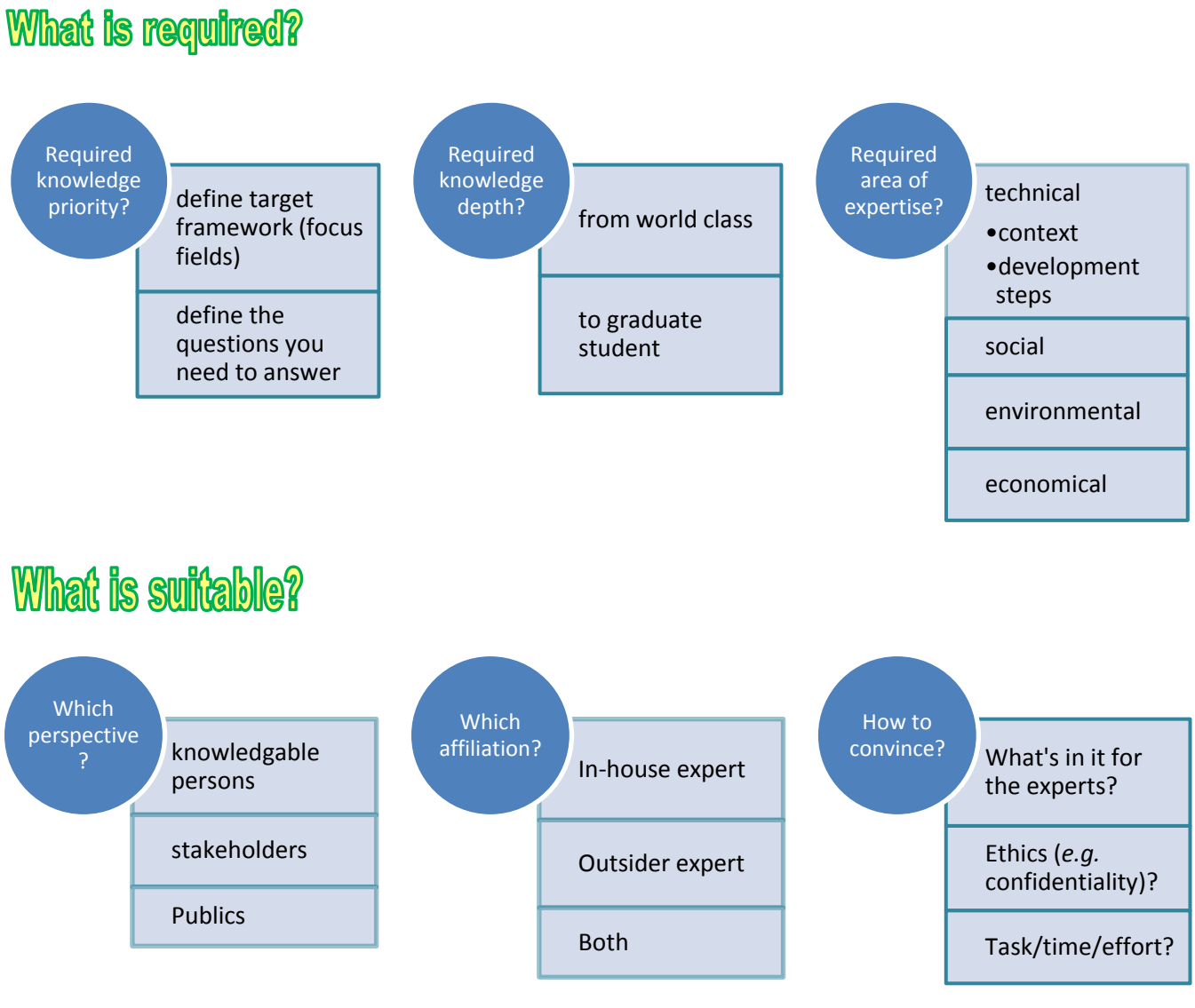
Selecting the expert is the most difficult part of designing an expert opinion technique. In particular, in order to get the characterization of the knowledge and skills of an expert, you have to pass through a bottleneck of an expert system. Robert R. Hoffman provided a working classification for methods to characterize and evaluate

an expert's knowledge [4]. Further explanation of bias reasons due to experts are explained in deliverable 2.5 [1] and the work of Goodwin and Wright [3], Mishra *et. al.* [5] and Martin [6].

The following part will concentrate on recommending non-exclusive/partial guideline criteria to be taken into account when choosing the suitable expert for a forecasting project. Figure 2 provides guidelines criteria by a systematic checklist to consider in the first step of designing an expert-opinion technique: choosing experts. These guidelines are considered here as recommendations to reduce the bias due to experts (see left part of figure 1).

Instead of jumping directly to the question of who to invite to the technique, the dilemma of choosing the right expert for a forecasting project can be encountered by three steps:

1- **Define what is required for your project** (in accordance with the aims, resources and questions of the forecast);
2- **Define what is the approach suitable for your project** (in accordance with different categories of experts and expert availability);
3- Define who is/are suitable for your project (in accordance with available published information about the expert and the willingness of expert to cooperate in other personal assessment methods).



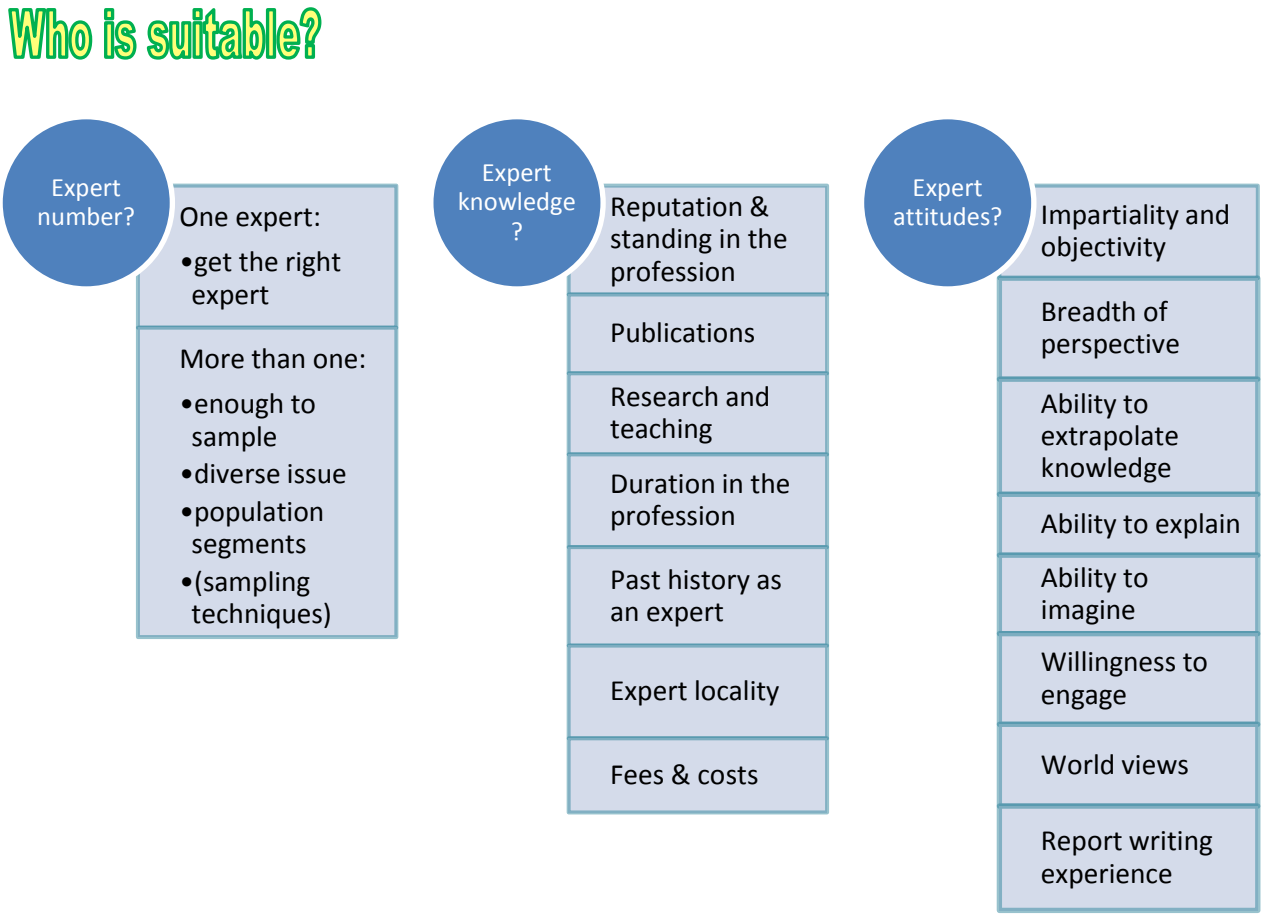


Figure 2: Guidelines checklist for the criteria of choosing the suitable experts for a certain forecast project.

2.2. Where to find experts?

- Networking with experts you know
- Professional society databases
- Patent databases
- Citations in books & papers
- Academic department lists
- Identifying relevant stakeholders [7]: the actors engaged in the technology during implementation, usage or dealing with technology consequences [8].

The experts can, therefore, be found either inside the organization benefitting from the forecast or outside it. Some strengths and weaknesses of both kinds of experts are represented in table 1.

Table 1: Strengths and weaknesses of in-house and outsider experts

	In-house experts	Outsider experts
Strengths	• understand decision context • understand organizational culture • can be easier to be identifed for participating in the project • are committed to the resulting decisions	• bring fresh perspectives • implement their previous experience of similar situations, *e.g.* system requirements, parameters, pitfalls, similar forecasting projects • provide valuable information not reachable by forecasters, *e.g.* industry stability, change directions, introducing new products.
Weaknesses	• Can provide a source of bias if forecast makers are the same to use it, *e.g.* a group working on a new product will unlikely forecast its failure. • Can provide a source of bias if the experts share lots of features "shared biases", *e.g.* shared backgrounds, prevailing wisdom, cultural norms or simply by having the same sources of news.	• If little information is available about the experts, this can introduce a source of bias either by: o having their expertise non-suitable to the forecast expertise o the existence of an unknown bias related to the background of the expert that is difficult to identify. o The existence of shared backgrounds, opinions or general perspectives between experts This might be controlled by asking the experts to provide a self-assessment prior to forecast project.

Depending on the used forecasting method, an expert can contribute to the forecast by providing a future perspective. However, this option is not so far included in the FORMAT methodology.

2.3. General recommendations during experts' selection

- Avoid Shared bias between experts:
  - Shared cultural norms
  - Shared backgrounds
  - Prevailing wisdom
  - Reading the same news sources

- Avoid not knowing the experts well enough:
    - To know the source of bias

- Avoid non-suitable expertise of experts

- Avoid optimism bias due to mixing forecast beneficiary and forecast developers (builders and users):
    - Optimism bias may happen on short-term forecasting
    - Pessimism bias may happen on long-term forecasting

Concerning the last recommendation, Hyndman and Athanasopoulos (2013) [9] indicated that: "Forecast accuracy may be impeded if the forecasting task is carried out by users of the forecasts, such as those responsible for implementing plans of action about which the forecast is concerned". This is due to the conflict of personal or political agendas (where targets and forecast are not separated), as well as users' optimism. For example, a team working on launching a new product can hardly forecast its failure [8].

In this particular issue, it is worth noticing that the FORMAT methodology for technology forecasting describes another definition for the users of the forecast who are responsible for implementing plans of action and for the decision making process. This category is defined as "*beneficiary*", while the in-house experts in this white paper can be referred to in FORMAT methodology under the "*user*" definition. Therefore, the FORMAT methodology has completely segregated the beneficiary from the forecasting activities for objectivity reasons[1].

3. Setting up the technique: (forecaster-expert communication)

There are various techniques dealing with extracting the knowledge from experts. Among these techniques, we can find: Delphi, committees, brainstorming, nominal group processes, surveys, Shang inquiry, EFTE, POSTURE, FAR, unstructured interviews, structured interviews [2].
Gustafson *et. al.* [10] referred to various techniques for expert opinion- gathering that most of them can be generally composed of three processes:

- Talk: the experts' talk about their experience

- Estimate: estimation of a forecast

- Feedback: the forecasters provide a feedback to the experts based on certain estimate

Gustafson *et. al.* [10] considered experts as those that are asked to develop a certain forecast by themselves. However, in other occasions experts are used to provide specific insights that will help the forecasters to develop the forecast.

Nelms and Porter [11] suggested six weighing factors that should be considered when designing the expert opinion technique to be used:

[1] For a list of definitions in the FORMAT methodology, view the glossary section of FORMAT handbook http://handbook.format-project.eu/?page_id=358 .

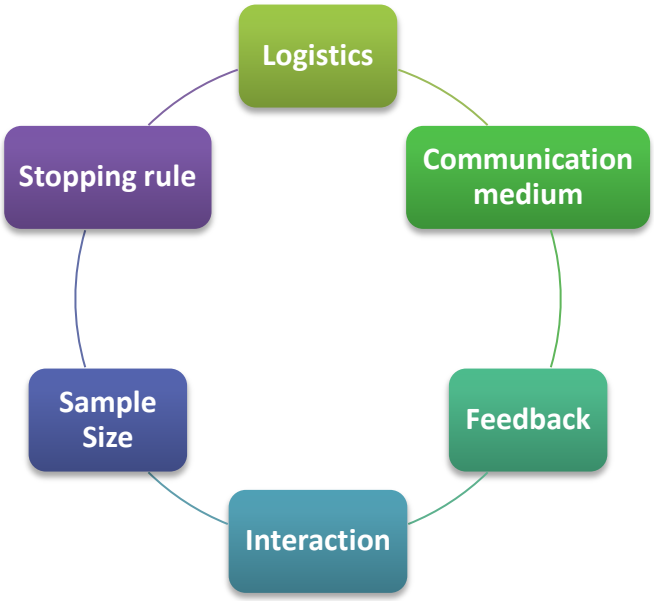


Figure 3: Six weighing factors (according to Nelms and Porter [11]) in designing the expert opinion technique.

- Logistics
  - Resources;
  - Time available (avoid multiple feedback technique)

- Communication medium
  - In person,
  - Electronic,
  - Real time, or
  - Whenever possible

- Feedback
  - Beware long delays in multistage processes

- Interaction
  - more is needed for more complex tasks

- Sample size
  - Once the experts interact with each other, it is not advised to have more than five or six experts.

- Stopping rule
  - In multistage processes, consider not more than two or three rounds as maximum

The usage of these factors will affect the strengths, weaknesses, costs and outputs of each designed technique. Porter *et. al.* [2] represented some of the many available techniques as represented in table 2, based on the choice and combination of the main processes: talk (T), estimate (E) and feedback (F) as described by Gustafson *et. al.* [10].

Table 2, Classification of expert opinion techniques [2]

Technique	Talk (T)	Feedback (F)	Estimate (E)	Process summary
Committees	X		X	TE
Brainstorming	X			T
Nominal group process	X	X	X	EFTE
Survey			X	E
Delphi		X	X	EFE
Shang Inquiry		X	X	EFE
EFTE	X	X	X	EFTE
POSTURE	X		X	ETE

In all these techniques the questions given to the experts should be chosen carefully.

Delphi method and focus groups have been explained previously in D.2.5 [1]. Another technique is the individual interview technique, which can provide individual inputs to the forecast. An interview can be either structured (with defined questions beforehand), non-structured (with no prior defined questions) or mixed interview (in which some questions are prepared before the interview while other questions are generated during the interview according to the expert talk). Mixed interviews and questionnaire techniques (similar to surveys) have been used for the assessment of the FORMAT methodology in deliverable 4.3 [12].

4. How to reduce the bias during the technique?

4.1. Recommendations to reduce bias due to forecaster-experts communication:

- **Consider Time:**
  Consider location, commitment and time availability of the experts [2]. Weigh requirements for detailed input against the time available [2]. For example, ask how many resources (manpower, money, time…) are there? [13]

- **Set task clear:**
  Set the forecasting task clearly and concisely: comprehensive definitions that are clearly communicated to everyone. A preliminary round of information gathering is recommended before setting out on performing the forecasting task [9]. Establish explicit and agreed criteria for adopting a forecast method [8].

- **Use the power of checklists:**
  Categories of information relevant to the forecasting task [8].

- **Be systematic:**
  Implement a systematic approach: checklists of categories, what information is important? How to weigh it? What are the criteria to be used for choosing the questions and measuring the results? What are the decision rules to the best approach? [9]

- **Check terms and vocabulary:**
  Check if all members know/speak the same technical vocabulary [2]. Check if world views are compatible between them [2]

- **Define how to formulate the statements** that will be described to experts and the questions to be asked? [13]

- **Establish explicit and agreed criteria for adopting a communication method**
    - Each expert should document and justify his opinion (leads to accountability) [9]
    - Require individual probability and severity ratings [14]

- **In interviews, chose the best interaction method to get individual output of the expert**
    - In person, by phone, or on internet (back-and-forth messaging)
    - Structured interview: (set of questions)
    - Non-structured interview: (draw out expert responses as they emerge)

- **For the design of your expert-opinion technique, ask yourself the following questions**:
    - What results can be expected? [13]
    - How do you intend to implement the results? [13]
    - Will there be follow-up activities, such as public relations activities, publications, workshops, presentations or conferences? [13]
    - What should be the breadth of the study? [13]
    - How many and which fields should I be asking for? [13]
    - How will the organization be? Who manages the process? [13]
    - Who will be invited to participate (active or non-active)? [13]
    - How is the questionnaire going to be designed?

- **For the design of your questions**:
    - Avoid insufficient background information:
        - Not too less, in order to avoid shortage of overview
        - Not too much, in order to avoid that expert response will be affected by forecaster's opinion
    - Avoid leading questions
    - Avoid ambiguous questions
    - Avoid unclear terminologies or technical details that are not understood by some experts (*e.g.* societal experts)
    - Randomize questions: (or avoid choosing randomly a specific sequence)

- **For the preparation of the questions to experts concerning a certain technology, some of the following questions could help as a good start [2]:**
    - What emerging technology merits ongoing attention?
    - What facets of this technology are specially promising?
    - How bright are the prospects of these technologies?
    - What are new frontiers for this technology?
    - What are the significant components of this technology? When will they mature?
    - How does this technology fit within the technological landscape?
    - What are the likely development paths for this technology?
    - What is driving this technological development?
    - What are key competing technologies?
    - What form of intellectual property protection should be pursued?
    - When will this technology be ready to apply?
    - How mature are the systems to which this technology applies?
    - What are the technology's commercial prospects?
    - Which aspects of the technology fit our needs?
    - What societal and market needs do this technology address?

- Who are potential users?
- What is the competitive environment and how is it changing?
- What environmental hazards does the technology pose?
- Have life cycle assessments been done? If so, what are key sustainability concerns?
- What stances are government and stakeholders taking towards this technology? And how might they encourage or oppose them?
- What pertinent standards or regulations are in place or are being considered?
- Which universities, research labs, or companies lead in developing or applying this technology? And which organizations should be watched
- What are the pertinent strengths and gaps within our own organization or this technology? Strengths and weaknesses of competitors?
- What companies are the present leaders in the market for applications?
- How strong and stable are the leading companies developing the technology?
- How do their strengths compare to ours? And what are existing partnerships?
- Which technically attractive organizations or individuals might make partnership or acquisitions with us?
- How entrepreneurial is the competitive environment?

- **For the analysis of the talks and the estimates from experts, define with your team the following:**
  - What kind of analysis needs to be possible?
  - Keep record of forecasts and use them appropriately to obtain feedback [8]
  - Study data in graphical rather than tabular form [8]
  - Draw a best-fitting line through the data series [8]

- **For the documentation and reporting:**
  - Document and justify: Formalizing and documenting the decision rules and assumptions [9]
  - Include reasons in controlled feedback [14]
  - Identify individuals who have experienced recent and relevant events [14]
  - Report results as medians rather than means [14]

- **For the validation of your results:**
  - Use more than one way of judging the degree of uncertainty in time series forecasts [8]
  - Someone, rather than the person(s) responsible for developing and implementing a plan of action, should estimate its probability of success [8]
  - Systematically evaluate forecast: monitor changes in forecasted environment and use it as a feedback to modify irregularities in the forecast, *e.g.* in decision rules and assumptions [8]

4.2. Recommendations to reduce bias due to expert-experts communication:

As explained previously, when interaction is allowed between experts, some psychological and social factors could appear. Therefore, it is recommended to avoid methods based solely on interactions of experts (*e.g.* a meeting of experts together that they arrive at certain recommendations). Some expert opinion techniques, like EFTE, allow experts' interaction after each expert has already submitted a justified opinion and then the forecasters have submitted a feedback to the experts with the summary and synthesis of experts' opinion.

Following are some problems that can happen during expert-expert interactions:

- Tendency to avoid criticism
- Establishing intellectual priority
- Experts with leading positions could dominate the opinion of their employees
- Experts with higher voice dominate the opinion of lower-voice experts [2]

- Intellectual ownership:
    - Behaviour of academics: some experts get annoyed by the fact that their ideas will not be referenced to them (usually a behaviour of academic experts)
    - Behaviour of policy researchers: these experts care more about the adoption of their ideas by policy decision makers

In the following table, a comparison is shown between anonymity and group meeting of participating experts.

Table 3: Anonymity versus group meeting of participating experts

Comparison feature	**Anonymity**	**Group meeting**
Influence of Political and social pressure on forecast	Not influenced	Influenced
Equal say between experts	Applicable, and all experts are accountable for their forecast	Some members may not contribute Some members can influence others based on seniority or personality
Group dynamics	-	Affected by seating arrangements Promotes enthusiasm and influence optimism and overconfidence
Physical location of meeting	Not needed	Needed
Likelihood of gathering experts with diverse skills from varying locations	Higher	-
Cost	Lower (no need to travel)	Relatively higher
Flexibility	Experts only have to meet a common dead-line for submitting forecasts	Experts have to set a common meeting time
Time	Can be time consuming	Final forecast can be reached in hours or even minutes
Experts' interaction	Lower	• Higher • Can lead to quicker and better clarifications of qualitative justifications

5. Conclusions and Remarks:

In general, the expert opinion method provides advantages, such as:

- Experts are a valuable source for the detailed history of a certain technology and its evolution steps in the past.
- In the presence of a group of experts, a model that is not fully or clearly formulated by an expert can be understood and incorporate by other experts leading to successfully produce high quality models.

However, the bottleneck of this method lies in some criteria, such as:

- Difficulty to identify experts
- Bias results from the knowledge of expert (especially if only one expert is involved)
- Bias results from the design of the interaction between the forecaster(s) and the experts (*e.g.* ambiguous questions or weakly designed techniques)
- Bias results from allowing the interaction between experts (*e.g.* social and psychological factors could affect the forecast)

There are however various sources of bias depending on the type of human interaction:

- Bias due to expert: can be controlled by defining priorities, choosing the right expert(s) and sampling techniques.
- Bias due to expert-expert communication: can be controlled by designing the interaction rules between experts.
- Bias due to forecaster-expert communication: can be controlled by designing the setting up of the technique (processes involved, weighing factors for these processes, criteria for choosing questions, criteria for analysing answers and criteria for running further rounds of the technique)

This white paper provided several recommendation to reduce the bias during expert opinion techniques. It should be considered as a guideline and not as a conclusive step by step limit to the forecast design. Some steps could be helpful as tools for formulating the forecast questions, while others can bring the forecasters and the experts to consensus about the roles and culture to be followed during the forecasting projects. This in turns should reduce the time consumption in the forecast activity.

The recommendation in this white paper are advised to be considered:

- At the first stages of the forecasting activities (Defining forecast questions and planning the project)
- During the whole duration of running the expert opinion technique by monitoring and assessment
- At the end of the forecasting activities for assessment purposes.
- Evaluation of the forecast at the end of the forecast period.

The recommendations mentioned here can also be useful for collecting information for other purposes. It has been very helpful for running an assessment of team experience during the forecasting case studies in the FORMAT project [12].

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