The Future of ICT-Based Futures Research
Scenarios for 2020

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Foreword

Let’s imagine that in only seven years time, the inquisitive researcher, politician, or manager only has to push a button and his computer will be able to tell him how his market, world, or society will be in 10 years, what he should do or should not do, and which path will lead to success. An interesting but unrealistic prospect. However, in the following pages you will find the most probable scenarios for the future. One thing is certain: The developments in ICT-based foresight tools are diverse and dynamic, and will provide decision makers with improved means to make qualified predictions about the future. Even more important: They will be better able to constructively influence the future.

As this report demonstrates, we will have significantly improved access to high quality data in the future and will be better able to network with other stakeholders. The new ICT-based foresight tools will enable us to combine various methods in foresight and gain a deeper, more meaningful understanding of future developments. At the same time, the study warns against information overload: We shouldn’t consider everything that comes out of the computer to be valuable. The one decisive thing that affects the future is and remains human beings. The tools, as sophisticated as they might be, are only tools. Executed within the scope of the Competitiveness Monitor project of the Leading-Edge Cluster Logistics (EffizienzCluster LogistikRuhr), this study is also a survey on the living object, so to speak. Even the Competitiveness Monitor is an ICT-tool, where several methods of foresight can be intelligently linked into a Foresight Support System.

The results of the study convey a practical impression of the developments which await us and should inspire a broader range of decision makers to recognise the benefits of such tools, to use them, to develop new tools, and to combine methods creatively in new ways. The study provides insights in a topic, which has not yet been researched in this manner. We owe thanks to the 177 experts from research, industry, consulting, and administration, who participated in the study. Moreover, we are highly appreciative of the fruitful discussions held with the participants of the 3rd Oxford Futures Forum 2011, and in particular its initiators Rafael Ramirez and Angela Wilkinson. We are confident that advanced technologies, like the ones investigated, will contribute to genuine and sustainable developments in the future.

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Executive Summary

1. Advancing ICT in Futures Research

Since its emergence as a discipline in the 1960s, futures research – the systematic examination of the future while following established quality criteria in research – has made significant strides in penetrating different aspects of our lives. Especially the increasing pace of change has created demand for techniques that make our future-oriented decisions more robust. Our research underlines that foresight activities are increasingly being implemented and supported by a diverse range of tools based on Information and Communication Technology (ICT), for example trend databases, prediction markets, and scenario-building software. Nowadays, lectures and workshops can be held online and data mining is beginning to revolutionise quantitative forecasts. Advanced software is learning to code qualitative arguments and to connect this data to related content on the web. Recently, the term “Foresight Support Systems” (FSS) evolved to describe the systematic study of computer-aided methodology of forecasting as an emerging separate field of research [1-3]. Such integrated, multi-method systems allow experts and stakeholders to collaborate throughout the entire foresight process. In addition, more powerful computers are being employed to calculate models of complex systems, such as the global climate. The study at hand reveals that we can expect significant advancements in technology to professionalise ICT-based futures research in organisations by 2020.

2. Consolidating a global Perspective of ICT-based Futures Research

This report is the result of an online real-time Delphi study [4, 5]. We invited approximately 1,000 experts from all fields of futures research: pioneers of the discipline, academics from universities worldwide, developers of software tools, practitioners from consultancies and industrial companies, as well as implementers from government and business associations. Members of the Global Business Network and the Club of Rome were also invited. In total, 177 experts from 38 countries took part in the survey, providing more than 2,000 written comments and arguments for future developments.

3. Keeping Futures Research a People’s Business

According to our Delphi expert panel, futures research will remain a people’s business even in 2020. Although ICT-based tools will tend to take on a more prominent role in strategic foresight activities, they will continue to rely on people’s input and creativity. Ultimately, actions will be taken by human decision makers, but ICT tools will help to make processes more efficient and provide valuable decision support. Over the next decades, the quality of these tools will improve significantly, thus the diversity of foresight methods will increase. Notably, crowd sourcing should contribute significantly to forecasting and the focus will shift from databases and communicative tools to interpretative software. Due to the diversity of instruments available, the challenge for future-oriented consultants will be to match the right tool to the right issue. This situation will also have an effect on consultants in the field. Being an expert in one method will no longer be sufficient. Therefore, practitioners will have to become proficient in multiple methods in order to tailor the foresight process according to the clients’ needs.

4. Bringing Futures Research to Society

Our study demonstrates that interest in futures studies is increasing independently from ICT development. Confronted with a growing amount of global long-term challenges – such as global warming or food security - societal discourse will embrace futures research on a much greater scale than today. However, ICT can generate added value by creating public awareness of futures research. Accessibility will be driven by the ubiquity of ICT technologies and the implicitness of using ICT devices for the increasingly digital society.
ICT-based foresight tools will be particularly helpful in tackling complex challenges. Growing computational power will not only enable use of more complex algorithms, but also provide tools to make teams more diverse and interdisciplinary. Due to their nature, ICT tools facilitate interaction, even in geographically remote areas. As a consequence, inter-departmental and inter-organisational projects will become increasingly common. Hence, scenarios will be adjusted to multiple stakeholders’ views and more realistic images of the future will become possible. Remote interaction also poses communicative challenges. Thus, there will be a need to design tools and projects in the simplest ways possible. Information provided by ICT tools should be comprehensible as well as non-ambiguous and creativity should be encouraged. Any ICT tool should merely be a supportive instrument for a people-oriented communicative process in which the user remains in control. With multi-methodological support, it should be possible to tackle issues by triangulation: using different methods to work on the same challenge – thereby cross-checking results [cf. e.g. 6, 7]. In this way, users will be able to analyse the results instead of simply letting the machine perform the work. In order to achieve good quality results from ICT tools, good quality data needs to be compiled and applied.

Since professional expertise is a prerequisite for participants in traditional foresight exercises, a reliable selection process is necessary. In addition, it is important that participants understand the goals of the process. In order to attain the right information, it is important to consider the subject matter – is the question at hand confined to a certain area of expertise or does it require unorthodox thinking? It might be more appropriate to involve highly specialised experts for a short-term to mid-term technological scenario, whereas visionaries with a broader scope of imagination might be better suited for unanchored events.

Parallel to these developments, it is important that the field of futures research continues to develop as an academic discipline. The methods used in ICT-based foresight tools will have to be based on scientific research and internationally developed quality standards. Only if these prerequisites are fulfilled methodological rigour and data quality can be guaranteed. Our study demonstrates a high desirability among experts for such standards. However, except for peer review control, scientific research methods and international quality standards have not yet been established. Therefore, there is widespread scepticism that this will be achieved by 2020.

Our study reveals that considerable potential lies in ICT-based foresight tools, especially in their capability to foster participation and engagement. These tools should facilitate involvement and communication among stakeholders and employees, thereby benefitting policy makers and stakeholders in formulating and achieving future-oriented, sustainable policy goals. ICT development will support corporate foresight activities. These practices will be more professional and better transferable into implementation measures. Most importantly, ICT-based foresight tools will render corporate foresight affordable to small and medium-sized enterprises (SMEs).
Findings of Delphi Expert Survey– ICT-based Futures Research in 2020

In this section, the findings of the expert survey are presented. In order to draw a comprehensive picture, four themes are addressed: (1) data and process quality; (2) operationalisation of foresight methods; (3) advanced ICT-based foresight tools; as well as (4) implications and stakeholders. For each future projection of the study, we first present the estimates of the expert panel for probability of occurrence, impact of occurrence on the foresight industry (1=lowest; 5=highest), and desirability of occurrence (1=lowest; 5=highest). Consensus or dissent among the expert panel is measured by the interquartile range (IQR), where a value smaller than or equal to 25 indicates agreement and thus consensus. We then document the experts’ top arguments for high and low probability of occurrence and discuss differences among stakeholder groups within the Delphi panel. Furthermore, pro and contra arguments for impact and desirability of occurrence form the basis of the implications section, and future implications are derived from these arguments. Finally, we present examples of noteworthy case studies, products, and applications throughout the test.

1. Can the potential Advantages of ICT in Foresight be realised?

ICT has changed our society. Information has become omnipresent and the efficiency of business and planning processes has been greatly improved by numerous innovative tools. ICT has already been introduced to the field of futures research. Trend databases, scenario planning tools, and prediction markets have been applied and extensive extrapolations and forecasts have been calculated. Presently, ICT application is used more prevalently in other fields of management. However, ICT applications might soon be able to shorten more qualitative, tedious processes in futures research – for example to identify the most reliable foresight data [8]. It is equally fathomable that ICT will not only increase the efficiency in foresight practice but also the quality. Inputting collected data into intelligent algorithms provides predictive power that was not previously able to be ascertained. Research has shown that it is possible to predict human movement at 93% accuracy using only mobile telephone data as input [9]. With increasingly interconnected data – Ericsson estimates 50 billion interconnected devices by 2020 [10] – there is a great deal of potential. An often suggested trend to upgrade the quality of futures research results with ICT tools is to combine and integrate different tools in order to triangulate data [6,11,12]. However, limitations to this development surely exist. Even Eric Schmidt, member of the US President’s Council of Advisors on Science and Technology PCAST and former Google CEO, warned that information overload could affect people’s ability to concentrate [13]. Moreover, the rising popularity as well as increasing prevalence of cloud computing creates data that is much more vulnerable to hacking and cyber attacks [14]. Manipulation of relevant futures data could alter the public discourse on relevant topics, as happened with the "Climategate" scandal: the Climate Research Unit email controversy [15], where researchers allegedly manipulated climate data in order to suppress other research critical of the climate change hypothesis.

As highlighted by the American psychologist Philip E. Tetlock, one solution to this problem could be international quality standards and certifications. The author suggests forming a permanent body of evaluators to review the actions of forecasters [16].
**Projection 1**

2020: The efficiency of future-oriented planning processes could be significantly enhanced by the application of ICT-based foresight tools.

<table>
<thead>
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<th></th>
<th>Expected Probability</th>
<th>Impact</th>
<th>Desirability</th>
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<tbody>
<tr>
<td>IQR</td>
<td>30</td>
<td>3.6</td>
<td>3.7</td>
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<tr>
<td>No consensus</td>
<td></td>
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The experts, who are most optimistic about this projection, stem from academia. They assign a notably higher probability of occurrence and a higher desirability to this projection than experts from other fields. They also expect a dominant impact in case of occurrence. Whereas other experts from the industrial field are more optimistic about overall improvements in ICT, academics primarily perceive potential in harvesting low-hanging fruits. As a consequence, efficiency gains could be achieved. The high impact assigned to this projection indicates that academics are already convinced of the potential of foresight development and believe that proper implementation is essential for generating beneficial results.

**Example: Estimize**

Estimize is an online platform that aims at improving the quality of financial analysts’ forecasts regarding the future earnings of a company. Anyone can log on to the platform and compare their own earning projections with those of other users. The combined forecasts are designed to marginalise the so-called “whisper-numbers” – unofficial earning estimates by sell-side analysts that are usually lower than published consensus numbers. Software, such as Estimize, improves the quality of futures data and makes it more easily accessible [17].

<table>
<thead>
<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ICT tools provide the user with access to many different sources of information, like the company’s ERP system or databases.</td>
<td>• The abundance of data causes information overload which the human recipient of information cannot cope with.</td>
</tr>
<tr>
<td>• ICT communication features grant access to social networks and geographically remote experts. ICT operations can more easily include data from diverse fields and disciplines.</td>
<td>• Futures research results in too many different bits and pieces of information for routine tools to make sense of.</td>
</tr>
<tr>
<td>• ICT tools enable different and diverse departments to work together and bring complimentary capabilities to the table.</td>
<td>• Foresight is a rather unstructured process relying almost exclusively on human interpretation, creative thinking and individual decision making.</td>
</tr>
<tr>
<td>• ICT tools significantly speed up routine operations which do not require much attention and/or human interpretation.</td>
<td>• Any ICT tool duplicating complex processes needs such a high degree of maintenance that gains in efficiency are only marginal.</td>
</tr>
<tr>
<td>• The integration of tools harmonises intra- and inter-team processes, resulting in reductions in transaction costs (in terms of time and money). Creative processes become more efficient and goal-oriented.</td>
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Findings of Delphi Expert Survey

The analysis for projection 2 shows that experts from government and business associations as well as from applied research are less positive about this projection than those from academia, industry, and consultancies. They assign lower probabilities of occurrence and lower degrees of desirability. In considering all projections, especially experts from politics and business associations can be identified as sceptics towards futures research.

<table>
<thead>
<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
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<tbody>
<tr>
<td>• ICT-based foresight tools are at the beginning of their development. Most innovations gain in quality over time.</td>
<td>• Technical ICT tools may provide supportive functions, yet they can hardly influence the quality of information in a qualitative process. Extrapolation of weak computerised data even magnifies the degree of small errors and decreases the quality of foresight data.</td>
</tr>
<tr>
<td>• There is a rising awareness for methods of futures research, for example in military or intelligence organisations.</td>
<td>• No computer can judge the quality of gathered or generated data without respective human input. Input of poor quality data automatically leads to poor quality output.</td>
</tr>
<tr>
<td>• A large amount of research is already being conducted in this area.</td>
<td>• The usefulness of more and broader data in strategic foresight practice can be subject to doubt. An overarching amount of data makes decision making even more complicated.</td>
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<tr>
<td>• ICT allows for the inclusion and collaboration of many different actors. For instance, prediction markets introduce the advantages of crowd wisdom to strategic decision making.</td>
<td></td>
</tr>
<tr>
<td>• Data-mining tools will improve in detecting hidden patterns in data pools and, thus, support the modelling of increasingly complex systems.</td>
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**Example: The Global Futures Intelligence System**

The Millennium Project integrates its information, groups, and software into a Global Futures Intelligence System (GFIS). This system provides users with access to all of the resources in one place. Subscribers can interact with all the elements of the system, make suggestions, initiate discussions with experts around the world, and search through over 10,000 pages of futures research and 1,300 pages of methods. The text has built-in Google translations in 52 languages [18].
Experts from government and business associations perceive this projection as more likely to happen than their counterparts from industry and academia. Yet, they also view an increase of manipulated data as slightly less undesirable. Since government officials can be considered futures research sceptics (see projection 2), it is not surprising that they also expect a considerably lower impact in probability of occurrence. If these experts consider futures research not playing a dominant role in the future, then it is of no interest to them if data is manipulated or not.

Our analyses revealed a significant desirability bias for projection 3. This means that the low desirability assigned to projection 3 may possibly have biased the experts towards estimating a lower than realistic probability of occurrence. Our post-hoc procedure for adjustment (please refer to methodology section) showed an estimated adjustment of 11 percentage points for this projection. Thus, the estimated probability of occurrence might be as high as 71.5%!

### Example: Trend Databases

Trend databases are already a widely used tool in corporate foresight. Several providers collect, describe, visualize and systemize futures knowledge. Such knowledge may include already manifested trends, weak signals, or wild card events. Input into the databases ranges from databases solely filled by experts and scouts, to those filled collaboratively by a community of members. Several of the providers offer further analysis tools to work with the data. Examples of existing trend databases include iKnow [19], Shaping Tomorrow [20], TechCast [21], TrendONE [22], trendwatching.com [23], TrendWiki [24], and Z-Punkt [25].

<table>
<thead>
<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
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<tr>
<td>- More data in combination with more complex tools will make it much easier to change data. The incentive to manipulate data – e.g. for public relations purposes – will increase.</td>
<td>- Foresight data is about the future and therefore hard to manipulate. By nature, data about the future is highly subjective. There is no incentive to manipulate data.</td>
</tr>
<tr>
<td>- Since much more data will be published, post-hoc scrutiny of the data – even when it is published as part of a study or an academic publication – will become much harder to achieve.</td>
<td>- Many foresight studies or academic publications publicise data and reveal important data for public scrutiny.</td>
</tr>
<tr>
<td>- The increasing prevalence of cloud computing creates data that is much more vulnerable to hacking and cyber-attacks (also see [14]).</td>
<td>- The data used is seldom sensitive information and most foresight activities do not rely exclusively on quantitative data.</td>
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<tr>
<td></td>
<td>- For intuitive decision making, there is no reason to manipulate data.</td>
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</table>
Findings of Delphi Expert Survey

Our analysis of projection 4 shows that experts from applied research assign the highest values in all three categories. As representatives of global research institutes accustomed to working collaboratively and under strict quality scrutiny, they stem from an environment in which quality standards are common and very important. However, their estimates of probability of occurrence for international quality standards are quite low. Consequently, it is not very surprising that applied researchers estimate a comparatively low probability of occurrence for quality improvements (see projection 2). Overall, experts from applied research institutions can be viewed as the quality advocates of futures research.

<table>
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<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
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<tr>
<td>• Since most foresight methods are subject to scrutiny in multiple peer-reviewed journal articles, proven methods will become more prevalent and results more robust and sound. This will serve as a quality standard.</td>
<td>• The interdisciplinary and qualitative nature of futures research makes universally applicable quality standards difficult.</td>
</tr>
<tr>
<td>• Increasing usage of futures research in the business world will automatically induce standardisation. Best practices in well-performing companies will encourage other companies to rely on the same methods.</td>
<td>• There is no central or commonly accepted institution able to set the standards.</td>
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<td>• Most of the work done is creative and, thus, would be stifled by adherence to rigid standards.</td>
</tr>
<tr>
<td></td>
<td>• There is no incentive for developers to design proprietary methods and tools according to standards. Visibility counts foremost, not quality. Product differentiation, i.e. using different standards, is a more important way to gain exposure.</td>
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2020: Internationally recognised quality standards have been established in futures research.

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<tr>
<th>Expected Probability</th>
<th>Impact</th>
<th>Desirability</th>
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<tr>
<td>45.1</td>
<td>3.2</td>
<td>3.6</td>
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IQR 30 No consensus

Example: The Good Judgement Project

As one of five teams in the Intelligence Advanced Research Projects Activity (IARPA) forecasting competition, the Good Judgment Project [26] based at the University of Pennsylvania and the University of California Berkeley competes in predicting major world events and trends. Forecasters from all over the world were recruited to contribute online via 12 different forecasting conditions (e.g. prediction markets and team forecasting are used). In this way, crowd wisdom is harnessed and the project aims to understand how personal and collective forecasting strengths differ, how to improve personal forecasting intelligence, and how to design systems that make groups smarter. More than 2,700 forecasters contribute their insights.
Projection 5

2020: An intelligent interconnection of ICT-based foresight tools (e.g., integrated software packages, harmonisation of interfaces) allows for higher quality in future-oriented planning processes than individual ICT-based foresight applications.

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<tr>
<th>Expected Probability</th>
<th>Impact</th>
<th>Desirability</th>
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<tr>
<td>62.4</td>
<td>3.6</td>
<td>3.8</td>
</tr>
<tr>
<td>IQR 30</td>
<td>No consensus</td>
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Although all expert groups believe that integrated ICT tools will be more common in 2020, the consultants are most optimistic about this projection. However, consultants also expect integrated ICT tools to have a significantly lower impact of occurrence. As their primary users, futures research consultants are likely to have the best overview of the tools already available. Thus, this result indicates that the development of integrated tools might be more advanced than many experts expect.

**PRO Arguments**
- There is already market demand for interconnected or integrated ICT tools.
- ICT tools will become better connected to ERP systems.
- Online storage of data and software will massively facilitate the convertibility of different tools as well as communication and collaborative work of remote partners.
- Triangulating solutions to problems improves the resulting quality.
- Companies and organisation have to increasingly deal with complex systems. This development will drive the realisation of integrated ICT-based foresight tools.
- Only with a combination of methods and sources can sufficient data be gathered and processed. Survey tools, databases, scenario building software, prediction markets, and statistical modelling packages will be combined.

**CONTRA Arguments**
- The intelligent interconnection of ICT tools will take longer than the eight year time horizon of this study. Comprehensive market consolidation is not yet foreseeable.
- The developers or employing practitioners of already established ICT tools are competitors. Competing entities have no incentive to share standards or source codes with each other, thus rendering the compatibility of tools impossible.
- The qualitative improvements which can be achieved by interconnected ICT tools are doubtable. Mixing different methods may actually worsen the quality of results.
Implications for Projections 1 to 5 for Theme #1: Data and Process Quality

Efficient, high-quality foresight methods would increase the market reach of ICT-based foresight tools. The facilitated inclusion of various stakeholders and remote experts has the potential to decentralise and democratise strategic decision making, thereby opening up additional innovative options for process optimisation. Without a doubt, some managers will adhere to their traditional procedures and exercises. However, best practice examples employing ICT for simplified decision making would make it hard to avoid employing them. The reach and reputation of futures research could further be enhanced by applying rigorous international standards to foresight methods and processes. By facilitating compatibility, such standardisation would benefit efforts to integrate tools that combine different methods and use data from different sources. Such triangulation could, in the experts’ opinions, be a cost-efficient way to achieve better data and quality for foresight activities. Triangulating foresight questions might support in addressing the complexity decision makers face today and will face in the future to a greater degree.

In the end, improved result and data quality would also ameliorate decision quality. Such high quality foresight procedures are among the most vital ingredients for sustainable action and business behaviour. However, this also means that better data quality should translate into better decisions – a result that is not guaranteed simply because this process involves additional hurdles in analysis, interpretation, and feasibility. Altering and improving such qualitative practices will be a tall order for ICT-based foresight tools, but more efficient processes would increase the time available for the decision making process.

The experts also perceive negative consequences if projections 1 to 5 were to occur. Decision makers could be tempted to rely invariably on answers provided by computers and algorithms. Since all managers should be held accountable for their decisions, this would pose ethical issues. Computerisation could also curb the creative capabilities of organisations and their people. This latter point could be amplified if standards are implemented. Standards could enforce conformity in all present methods and might even marginalise external opinions and unconventional approaches. However, standards could – on the other hand – support in constraining data manipulation. In many experts’ opinions, data manipulation will be a direct function of increases in the volume of futures relevant data and usage of ICT-based foresight tools. Although the impact of manipulation would undoubtedly be mitigated by the higher data volume and the resulting broader knowledge base, high profile cases could damage the reputation of futures research in a similar way that the reputation of climate change research was damaged by the Climategate scandal [15]. In particular, experts fear that manipulated data and processes might be used for public relations purposes of organisations and enterprises, thereby damaging the reputation of futures research in the process. Increasing the comparability and transparency of quality standards – if they could be enforced – would prevent such situations from happening.

Key Findings and Recommendations

It is likely that integrated Foresight Support Systems (FSS) will be increasingly common in corporate processes. Organisations should prepare their staff by scanning the market for emerging dominant tools and establishing practical and ethical guidelines for FSS usage. In order to benefit the most from this development, organisations should integrate all relevant departments and locations in ICT-supported foresight activities.

Organisations should not underestimate the threat of manipulated future-oriented data. Tools should only be used if the input data is of high quality and stems from a reliable source. Organisations should also be aware that results of FSS are not automatically taken at face value. Decision makers and staff should continue to exercise critical judgment and nurture creativity.

Developers of ICT tools should embrace early-mover advantages in integrated foresight tools. Collaborating with competitors in co-operation might be a strategic advantage. Developers should also be aware of the threat of manipulation. Certified, secure software might become a unique selling point.
ICT obviously enhances our abilities to reach more people and elicit their opinions. The wisdom of the crowds theory implies that ICT increases the accuracy and the robustness of the retrieved data [27]. Since it is particularly important to regard all aspects when estimating possible developments, the foresight discipline could particularly benefit from group wisdom. In recent years, more concepts of information retrieval have been developed based on group approaches. Wikipedia is a prime example. Other examples include prediction markets as well as social media and social networks. This trend has also spilled over into the business world. Many companies employ prediction markets [28] and in 2010, 77% of managers responded in a survey that Web 2.0 applications helped to improve their employees’ access to internal information [29]. One important implication regarding group processes is whether or not to include external stakeholders. This development has already become an issue in innovation management [30] – a discipline strongly related to foresight [31]. The practice of “open foresight” [32, 33] would raise many questions and would therefore constitute a development, which should be taken seriously.

Open foresight and group processes would primarily be implemented via ICT tools. Combined with further progress in process optimisation due to ICT, this development would potentially drive consultants – as providers of process know-how and expert knowledge – out of business in this field. Ever since the industrial revolution, various kinds of jobs have been substituted: first by machines and then by computers – while new jobs have been created elsewhere. The argument has increasingly been made that this development could further extend to employment in the tertiary sector [e.g. 34]. According to some scholars, it holds true even for very sophisticated services [35]. However, many of the tools are proprietary software created by these consultants, who also provide important intangible services.

**Example: Wikirating**

*Estimating the future ability to service debt has become a mainstay item in news reports. Financial agencies use mathematical forecasting models in order to calculate credit scores for corporate bonds and sovereign bonds as well as for structured financial products. Computing power and software packages are already an important part of the process. At the end of 2011, an open-source alternative was introduced [36]: Wikirating uses two different methods to calculate credit ratings. Every user can rate any country, company, or product. This method uses the wisdom of the crowds approach, relying on the aggregate information of all users. The second method is automatic and so far only available for sovereign credit ratings. Published macroeconomic data is aggregated in a pre-defined formula and multiplied by a scaling factor [37]. Ratings for more than 120 countries and more than 70 companies are available which differ widely from ratings assigned by professional companies. Time will tell if they are more accurate.*
Projection 6

2020: The reliance on individual expert knowledge has diminished while the trust in group wisdom and collective intelligence is emerging.

<table>
<thead>
<tr>
<th>Expected Probability</th>
<th>Impact</th>
<th>Desirability</th>
<th>IQR</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.3</td>
<td>3.4</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>

Of all experts, those from applied research assign the lowest probability of occurrence for projection 6. As quality advocates of futures research (see projection 4), they believe expert knowledge is more credible than group opinion. Consequently, applied researchers also express a distinctly negative desirability (below 3) for group wisdom.

Contrarily, experts from consultancies estimate a significantly higher probability of occurrence than the other groups. Since consultants are most likely to have worked with ICT-based foresight tools this could possibly reflect their previous experience in integrating group wisdom. Consultants were in agreement with industry experts in assigning a higher impact to projection 6 than the other experts.

**Example: InnoCentive**

InnoCentive is an example of an open innovation platform. Problems or requests for innovations can be publicised on the website in addition to the amount of money the requester is willing to pay for a solution to the problem or an invention. The website has already supported global players, such as Procter & Gamble, and has contributors from all over the world. Most of the time, people from other areas solve problems that are beyond their own area of expertise [38]. InnoCentive [39] reports that more than 1,500 problems totalling more than $37 million have been posted on the website. Over 270,000 registered contributors have mastered more than 50% of these challenges. This evidence suggests that open innovations as a concept – if on a smaller scale – is applicable to futures research.
This projection has one of the strongest consensus results in the study. While consultants are the only group of participants, who assign a probability of above 50 percent for the standard occurrence of open foresight, all groups are very close to the 50 percent mark. The most distinct finding from group analysis is a high impact rating of 3.9 by the group of government and business association participants. This indicates that the other groups may have a slightly more positive picture of the current status of open foresight. While hardly any experts believe that it will be standard practice in 2020, they still believe it will be one practice among many others. Moreover, they argue that to some extent open foresight already exists today – as open innovation – therefore, its actual impact would not be great.

### Projection 7

**2020: Open foresight has become standard practice in business.**

<table>
<thead>
<tr>
<th>Expected Probability</th>
<th>49.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>3.6</td>
</tr>
<tr>
<td>Desirability</td>
<td>3.7</td>
</tr>
</tbody>
</table>

**IQR 20**

**Strong consensus**

- **PRO Arguments**
  - “Open” approaches, such as open innovation, open-source programming, or open journalism (blogging) are already prevalent in different societal fields.
  - Including opinions of those outside of the organisation in foresight activities provides additional perspectives and informs the company about implications to other stakeholders previously not considered.
  - Diversification of sources leads to diversification in the knowledge pool.
  - Open foresight will be cheaper than proprietary systems and thus be affordable for more companies.
  - A wide implementation will bring more investment and consequently lead to the establishment of standard tools for open foresight.

- **CONTRA Arguments**
  - Open foresight does not necessarily lead to more accurate results.
  - Incentivisation is an issue: It has proven to be a challenge to encourage people to participate in such formats, based on previous experience with open innovations and monetary rewards.
  - It remains unclear to what extent knowledge derived in an open process could be used in profit-seeking processes without risking legal liability.
  - “Open” processes are domains of a younger generation, which has grown up with “open-source values”. Conveying these values to traditional management poses large impediments for implementing open foresight as a standard procedure by 2020.
Findings of Delphi Expert Survey

Unsurprisingly, consultants assign both the highest impact and the lowest desirability to projection 8. While this projection is judged as improbable with a high degree of consensus, the results revealed a desirability bias for projection 8. Thus, the low desirability assigned to projection 8 might have biased the experts to perceive a lower than realistic probability of occurrence. Our post-hoc procedure for adjustment (please refer to the methodology section) showed an estimated adjustment of 9.3 percentage points for this projection. Thus, the estimated probability of occurrence might be as high as 39.7%!

### Example: Inkling Markets

Inkling Markets is a technological firm based in Silicon Valley that offers prediction markets, such as ‘Software as a Service’ [40]. Prediction markets work similar to stock markets with the goal of expressing an aggregated approximation or probability of an event happening by means of share-pricing. Companies can use prediction markets to internally forecast important performance indicators, such as sales numbers or prices. They can also open up the market to involve external stakeholders, for instance distributors or suppliers. Inkling Markets uses an easy format: the current estimated probability of a given event. The user can judge whether he believes this probability to be too low or too high, whereupon the software will automatically buy or sell stocks for the user in order to express this assessment.

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### PRO Arguments

- Higher investments in ICT-based tools by the military, intelligence agencies, and other organisations suggest that higher quality and intense automatisation will be achieved in a relatively short timeframe.
- Exponential growth will lead to rapid progress in ICT technology.
- The implementation of tools leads to cost reduction. Clients save money if expensive consultants are replaced by ICT-based consultancies.
- Using these tools could increase the integration of ongoing foresight procedures in company operations.

### CONTRA Arguments

- ICT tools are often produced by futures consultancies and sold/purchased in packages. Consultancies will continue to implement the tools for companies and also provide the creative brain power to interpret the results for decision makers.
- Although ICT-based solutions are becoming important in business processes, the results need to be interpreted by humans.
- Consultancy legitimises decisions and provides additional support to managers’ decisions or risky undertakings. ICT tools could only provide these functions in a limited manner.
Implications for Projections 6 to 8 for Theme #2: Operationalisation of Foresight Processes

The occurrence of projections 6 to 8 would imply that foresight practice will be employed with group wisdom-based ICT tools to involve outside stakeholders in 2020. Foresight consultants would have trouble finding and maintaining niche markets. Many survey participants argue that – if the group members are diverse and thoroughly selected – employing group wisdom would provide businesses with a much larger data basis of multiple perspectives, which would contribute to improved decision making. Integrating more people in strategic knowledge creation may also incentivise creativity and commitment by democratising organisations. Consensus building and open foresight activities should increase: Combining multiple stakeholder knowledge would include more perspectives for better results and democratise the relationships of stakeholders to benefit society, including substantially higher foresight activity.

However, the expert panel also suggest many negative effects of group wisdom and open foresight. Primarily, they are concerned about competitive and innovative advantages. A trend away from internal expertise would act as a powerful “leveller of the playing field” – organisations employing group wisdom and open foresight would eventually have the same knowledge. As a consequence, there would not be an incentive to think innovatively if the resulting ideas would soon become competitors’ knowledge. Consequently, important knowledge would have to be kept internal in order to maintain competitive advantages. Many experts agree that even if group wisdom and open foresight become standard practice, they can only aggregate already known wisdom and thus only play a supporting role in the innovativeness of individual firms and experts.

The displacement of consultants is perceived to be thoroughly undesirable by the participants. Consultants provide expert knowledge and face-to-face interaction in foresight methods – features that would likely be reduced with more reliance on ICT and group wisdom – and their services foster competitiveness and innovation in organisations. Furthermore, many survey participants distinguish consultants as important specialists in foresight methods, who contribute to the overall advancement of foresight methodology. Since many ICT tools are also developed by consultants, some experts believe that there would be a shift in business opportunities if projections 6 to 8 were to occur: tool development, maintenance, and data specialisation could become fields of interest. For futurists employed by consultancies, new opportunities may also evolve: Depending on the magnitude of foresight performed by companies, secure in-house jobs in foresight departments will be needed to apply and control the tools.

Key Findings and Recommendations

Although the popularity and application of group wisdom have been increasing for some time, it is unlikely that this development will extend to all kinds of decisions. Rather, it is likely that expert knowledge and group wisdom will complement each other. Especially for high profile decisions, expert knowledge should continue to be the dominant form of data retrieval. However, the advantages of group wisdom should not be disregarded: group wisdom implementation can instil a creative and democratic atmosphere to an organisation. Increased collaboration among experts would combine the advantages of both approaches. Selecting the right participants for group exercises is the crucial factor in attaining group opinion. Including external stakeholders in such exercises would benefit the open foresight implementation within the company. Since open foresight is expected to develop after 2020, this could provide firms with first-mover advantages. However, organisations should thoroughly analyse their competitive risks, check their legal position on intellectual property rights, and define clear processes. The payoff could include more robust foresight methods but also a strengthened network.

It is unlikely that foresight consultants will lose much business to such developments, especially since the ICT tools used to implement group processes are primarily their proprietary tools. Consequently, set-up, maintenance, application, and interpretation of these processes offer additional opportunities for consultancies. The main priority for developing group decision tools should be in motivating participation. Developing comprehensive solutions for open foresight activities could be another important early-mover advantage. Since clients are likely to increasingly compare consultancies according to the tools they have to offer, constant improvement is a must. Consultancies should be prepared for both intensified competition and a consolidation of the market.
Findings of Delphi Expert Survey

Currently, ICT tool development in futures research is predominantly concerned with gathering and providing data, which can be used in scenario building or other decision support situations. Software packages for replicating these methods already exist to some degree. However, advancements are still being made to techniques, such as web mining, crowd-sourcing, and Delphi surveys. Some scholars suggest that government-funded, web-scanning mechanisms [41] could be provided, virtually taking data retrieval out of our hands.

By 2020, there may be a shift of focus towards developing and integrating more result-oriented, interpretive tools, including ICT tools which are able to understand complex systems. Since the introduction of computers, many attempts have been made to model complex systems to project their future behaviour. Most high-profile, contemporary models attempt to project the long-term influence of carbon emissions on climate change. Although models to anticipate social systems are progressing, their development still lags behind [42, 43]. Similar to the challenge of interpreting the data, the actual derivation of decisions from interpretation and the implementation of these decisions are not yet sufficiently supported by ICT. However, this “scenario transfer” [44] is as crucial for the companies’ success as it is for the structured and exhaustive preparation of the scenarios themselves. The advantages of automatisation in futures research range from improved communication of scenarios via real-time monitoring, to motivation to use futures research via installation of micro-technology in all sorts of objects and devices [45], to multi-criteria decision support tools [46].

3. Can we drive the Leading Edge in Decision Support and Decision Making?

Example: FuturICT

FuturICT is a proposed large-scale project, piloted by several European universities, that aims at simulating complex social systems [47]. An open software platform called “Living Earth Simulator” would allow developers to upload modelling components. These would be combined to create large data modelling software, which would run the models (using different European supercomputers) to calculate future scenarios. A customised variety of methods and models could be used, simulating systems in different possible levels of detail depth. The data used would be collected through the so-called ‘Planetary Nervous System’: Data mining from many different sources (e.g. the Internet, voluntary smartphone users, etc.) would supply the models, if need be in real time. The results would be published on a Global Participatory Platform where communication, coordination, and collaboration among participants, advice-seekers, and decision makers would be organised.
Findings of Delphi Expert Survey

Of all projections in the study, this projection proved to be one of the most interesting concerning potential bias. Testing revealed a significant desirability bias, which suggests that the high desirability assigned to this projection may possibly have biased the experts to perceive a higher than realistic probability of occurrence. Our post-hoc procedure for adjustment (please refer to the methodology section) showed an estimated adjustment of 9 percentage points for this projection. Thus, the estimated probability of occurrence might be as low as 69.3%.

**Example: Parmenides EIDOS**

The stated goal of Parmenides Eidos Software is to close the gap between cognition and challenges that has emerged because cultural evolution (compared to biological evolution) has developed quickly and resulted in complexity [48]. Eidos can be used to identify underlying driving forces for multiple factors in future developments, thereby reducing the complexity of the cognitive challenge at hand. Subsequently, the software supports users in building scenarios from these driving factors and deriving strategies from scenario planning. The software also has functions in scenario and strategy monitoring.

<table>
<thead>
<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• We are on the way to achieving good availability of futures data. Reliably interpreting the data is the next great challenge of the futures profession.</td>
<td>• Retrieval and interpretation of data are absolutely dependent on each other. One cannot happen without the other and both will remain a challenge.</td>
</tr>
<tr>
<td>• Most of the data could be gathered automatically in the future: Applications, such as web mining, can be used for data input.</td>
<td>• The increasing complexity of the world will keep up with the pace of our respective abilities.</td>
</tr>
<tr>
<td>• Interpretation of relevant futures data is already the key challenge in futures research. Data does not have any impact if it is not interpreted.</td>
<td></td>
</tr>
</tbody>
</table>
In-depth analysis of the results for projection 10 revealed that experts from government and business associations are especially pessimistic about the estimated probability of occurrence. They operate in multi-stakeholder environments in which complex problems are common. Thus, scepticism about calculating such problems is not surprising. In general, the results show that the group of government and business association participants tend to rely more on intuition and power politics (see projection 2).

Testing revealed a significant desirability bias for this projection, meaning that the high desirability assigned to this projection may possibly have biased the experts to perceiving a higher than realistic probability of occurrence. Our post-hoc procedure for adjustment (please refer to the methodology section) showed an estimated adjustment of 8 percentage points. Thus, the estimated value might actually be lower than 50%.

<table>
<thead>
<tr>
<th>PRO Arguments</th>
<th>CONTRA Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increasing computing power will enable ICT tools to process more complex models.</td>
<td>• Unpredictability is a feature inherent to complex systems – a fact that cannot be changed by computing power, a greater amount of / broader data, or sophisticated modelling.</td>
</tr>
<tr>
<td>• ICT has the ability to deal with complexity which is superior to the human brain: computers have larger capacities for storing and processing quantitative information.</td>
<td>• The inclusion of wildcards and unpredictable events is problematic. Programming these into a model can only happen in an entirely arbitrary way.</td>
</tr>
<tr>
<td>• Online tools are capable of gathering and analysing data. Web mining and crowd sourcing tools could gather data at unprecedented scales; data mining tools reveal hidden patterns that shed light on correlations previously unrecognised.</td>
<td>• Humans will always have to execute the actual modelling of the tools.</td>
</tr>
<tr>
<td></td>
<td>• Major advancements in complex system anticipation will take longer to evolve than nine years.</td>
</tr>
</tbody>
</table>

### Fictional example: The Fear Index

In his 2011 thriller “The Fear Index” Robert Harris [49] wrote about a hedge fund manager, who conducts research on artificial intelligence. He applies his research to concoct a self-learning algorithm that uses web mining to identify emotional precedents to stock-market movement (such as communication on forums frequented by terrorists). Based on this information, the software autonomously buys and sells stocks, whereas quantitative analysts only monitor the trades without usually interfering. The algorithm primarily relies on exploiting people’s fear and eventually it deliberately induces a market crash, relying on other trading algorithms that react to its own trading in a predictable manner. As a consequence, the algorithm can cash in on a large number of short positions.
Projection 11

2020: ICT-based foresight tools have eliminated problems of scenario transfer into strategy.

<table>
<thead>
<tr>
<th></th>
<th>Expected Probability</th>
<th>Impact</th>
<th>Desirability</th>
<th>IQR Consensus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Probability</td>
<td>32.2</td>
<td>3.3</td>
<td>3.2</td>
<td></td>
</tr>
</tbody>
</table>

While survey experts from government and business associations estimate a lower probability of occurrence than the other groups, projection 11 is judged as improbable by all other experts. However, the importance of scenario transfer is underscored due to the high impact factor industry experts assign to projection 11. At 3.5, their rating is considerably higher than that of other experts, who are usually less involved in implementing insights gained during foresight activities.

**Example: RAHS (Bundeswehr)**

While testing available software packages before 2009, the German Armed Forces (Bundeswehr) found that existing support software for futures research did not meet their requirements for collaboration features. The Bundeswehr is therefore currently financing a Risk Assessment and Horizon Scanning (RAHS) project [50]. The project aims to produce a customised collaboration platform on methods and contents of security-related futures analysis. The RAHS framework provides different methods of futures research, which can be used digitally and collaboratively. RAHS supports the entire foresight process and allows for contributors to work from different places and in different time zones.

**PRO Arguments**

- Through ICT tools, scenarios can be constantly monitored in comparison to real developments and continuously adapted and renewed, thus providing more objective decision support.
- Scenarios can be communicated better, faster and more widely, ensuring that employees are up-to-date and everyone works towards the same goals.

**CONTRA Arguments**

- Transfer problems are mainly rooted in company structures and managerial processes and not in a lack of implementation technology. Organisational and behavioural difficulties will hardly be resolved by ICT solutions.
- Managers should not be able to defer accountability for organisational success or failure to ICT tools.
- Scenario transfer is an intuitive and creative process, which is too qualitative for quantitative ICT tools.
Findings of Delphi Expert Survey

Interpretation of futures data will be the key challenge in 2020. Organisations should thus focus on interpretative and creative capabilities when selecting and training decision makers. It is likely that new ICT tools for supporting qualitative processes will be developed. Organisations experimenting with these may enjoy early-mover advantages and benefit from their personnel's ability to use and possibly shape these tools. It seems unlikely that computer software will be capable of interpreting complex situations. However, some progress in modelling will be realised. While investments in this area seem large and somewhat risky, the potential payoffs of successful modelling, even with limited range, justify actively monitoring this development. The automation of scenario transfer via ICT tools seems so far off that organisations should rather focus on a structured and well-prepared scenario transfer process based on human interaction and involving the relevant stakeholders. The best strategy seems to be to apply integrated systems that anchor the scenario process and its results deeply in the organisation.

Implications for Projections 9 to 11 for Theme #3: Advanced ICT-Based Foresight Tools

The premise that interpretation rather than retrieval of future-oriented knowledge will be the main challenge of foresight in 2020 implies that a new frontier has been reached. Tools, such as complex modelling or scenario transfer mechanisms, will provide the exact type of support required to overcome this challenge.

Overall, the experts argue that the ubiquity of relevant information will have a positive impact on the quality of decision making. Time lost in acquiring information can be used more productively for thorough consideration of decision making implications. The result could be more sustainable and successful decision making. Therefore, it is not surprising that the occurrence of projection 9 is universally found to be desirable.

The occurrence of projections 10 and 11 would even advance this achievement – if however in a more controversial manner. Using ICT tools for truly complex modelling – for example anticipating the behaviour of social systems – would be counterintuitive to the simplification processes of the human mind. However, if successful, we could anticipate dangers and possibly manage these crucial crossroads in order to realise huge societal – or commercial – benefits. Such systems would also benefit decision makers, who are overwhelmed by the responsibility of interpreting abstract problems and presenting them with clear choices instead of the creative task of interpretation.

Similarly, the allure of optimised and standardised scenario transfer processes would facilitate the implementation of the scenario technique in organisations. Some experts argue that automation would also increase the transparency and, consequently, the quality and efficiency of scenario transfer in organisations. However, many experts also warn of trivialisation when applying complex modelling tools and/or ICT-based scenario transfer: complex challenges cannot be reduced to quantitative problems. On the contrary, especially in scenario processes and particularly in scenario transfer, the creativity of individuals is not substitutable. The application could result in vastly inferior outcomes. Moreover, the absence of these creative tasks might reduce managers' imaginations, leading to less-skilled decision makers in the future.

In addition to these general concerns, many experts have more specific apprehensions regarding such tools. The general feeling is that these would require rather high investments and consequently – if they would indeed generate the profits assumed by many – increase the gap between haves and have-nots. Furthermore, some experts fear that complex tools would be very difficult to use and contrary to perceived benefits, might actually constitute a barrier to the adoption of foresight in organisations. The complex nature of the tools might also nurture scepticism among those decision makers that do not understand them. Recommended action would not be implemented, thereby negating all impacts of technological progress.

Overall, progress in advanced ICT is welcomed by the experts. However, most agree that regardless of how advanced, ICT will not make the future predictable. At the very least, discontinuous change and unforeseeable events will pose insurmountable challenges for ICT-based foresight tools.

Key Findings and Recommendations

Interpretation of futures data will be the key challenge in 2020. Organisations should thus focus on interpretative and creative capabilities when selecting and training decision makers. It is likely that new ICT tools for supporting qualitative processes will be developed. Organisations experimenting with these may enjoy early-mover advantages and benefit from their personnel's ability to use and possibly shape these tools. It seems unlikely that computer software will be capable of interpreting complex situations. However, some progress in modelling will be realised. While investments in this area seem large and somewhat risky, the potential payoffs of successful modelling, even with limited range, justify actively monitoring this development. The automation of scenario transfer via ICT tools seems so far off that organisations should rather focus on a structured and well-prepared scenario transfer process based on human interaction and involving the relevant stakeholders. The best strategy seems to be to apply integrated systems that anchor the scenario process and its results deeply in the organisation.
4. How will ICT-based Futures Research be applied?

The final projections of this study consider the implications the previous results have on foresight practice and foresight’s standing in business and society. ICT has already changed the way we live in various areas. Electronic data processing and transfer have become standards in the business world, facilitating most of the formerly manually performed processes. Nearly every object purchased has been defined by the means of computer-aided design. However, in foresight and strategic decision making we still do not rely on ICT. For example, Klein [51] determined that 90% of all important decisions are still made using “gut” feeling. Research and development in ICT could “blur the distinctions between research and decision making” [52] in the coming years. Considering the technology affinity of younger generations, future foresight experts are more likely to be adept at using ICT. Innovative ICT tools could broaden the application of foresight from a niche discipline to more common practice. To some degree, this already seems to be happening since academic programmes to train foresight professionals are growing [53]. Therefore, the demand for ICT solutions in foresight could increase and ICT could ultimately design futures research and how it is conducted.

Projection 12

<table>
<thead>
<tr>
<th>2020: Information and communication technology (ICT) has revolutionised the practice of futures research.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Probability</td>
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<tr>
<td>Impact</td>
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<tr>
<td>Desirability</td>
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</table>

In-depth analysis of the results of projection 12 showed that experts from industrial enterprises are more optimistic about this projection than other experts. They assigned higher values to estimated probability, impact and desirability. This result indicates that these experts are ICT-optimists: they expect ICT to radically improve processes of long-term planning. In many cases, this expectation stems from previous experience with ICT introductions in other fields, which had implications for industrial enterprises. The discrepancy is especially high when it comes to impact. Thus, it can be argued that industrial companies profit most from efficient foresight. The other expert groups, particularly experts from government and business associations, are more conservative in their expectations. They perceive potentials for improvement but do not expect revolutionary developments.

PRO Arguments

- Changing practice in futures research is already an ongoing trend. Communication and sharing tools facilitate the collaboration among different departments, geographically removed locations, or even entire industries.
- Futures-oriented planning or scenario planning can be addressed in a more comprehensive and collaborative manner.
- The continuing growth in computing power provides ICT with interesting opportunities. A larger amount of data can be tapped from different sources. Combined with more efficient ICT tools for analytics, the broader data basis will lead to more accurate and comprehensive ideas of future developments.

CONTRA Arguments

- Futures studies are – and should remain – a human-driven process.
- Even though an increase in the utilisation of ICT is to be expected, the methods of foresight will largely remain the same. Consequently, the practice will not change substantially.
- Even newly developed ICT-based foresight tools will not be able to improve the overall quality of futures research.
Findings of Delphi Expert Survey

The strong consensus of projection 13 indicates that a growing demand for ICT-based foresight tools is a very strong expectation of the panel. Since experts from industry, the most important group of clients, express the highest desirability for the occurrence of this projection, we can substantiate this finding. The highest impact is expected by consultants because as implementers of foresight procedures, they are concerned the most about this projection.

Example: Precrime

Several police departments in the USA have started to use algorithms for predicting future crime. Crime data is continuously updated in the programme located in Santa Cruz, California. The algorithm was originally used to predict earthquakes and was modified to fit human behaviour. The data is analysed for patterns and thus can assign risks to areas, time frames and types of crimes. In addition to mathematics, the algorithm relies on anthropological and criminological reasoning and has proven to be successful in eliminating cognitive biases in crime fighting forces [55].

<table>
<thead>
<tr>
<th>+ PRO Arguments</th>
<th>- CONTRA Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Computers are more suitable and qualified to address complex problems and record quantitative data.</td>
<td>• ICT tools will not deliver better quality than non-ICT methods. Without adequate input, high quality results cannot be attained.</td>
</tr>
<tr>
<td>• Experience from other areas shows that the deployment of ICT solutions will translate into increased investments.</td>
<td>• Most managers think traditionally and will not change their ways without significant qualitative improvements to ICT-based foresight tools. Rigid organisational structures also hinder implementation.</td>
</tr>
<tr>
<td>• Demand for ICT-based foresight tools could profit from overall rising demand for ICT solutions and consequent spill-over effects.</td>
<td>• Proprietary ICT might be too expensive for small companies.</td>
</tr>
<tr>
<td>• The advantages of having ICT-based foresight tools will result in increased demand [see also 54].</td>
<td></td>
</tr>
</tbody>
</table>
Projection 14

<table>
<thead>
<tr>
<th>Expected Probability</th>
<th>51.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>3.4</td>
</tr>
<tr>
<td>Desirability</td>
<td>3.2</td>
</tr>
</tbody>
</table>

The group analysis of projection 14 shows that experts from industrial companies assign a lower probability of occurrence and a lower impact to it than other groups. This result demonstrates that although industry experts are generally ICT-optimists, they tend to view foresight activities in the context of overall business procedures. For them, it is more likely that foresight will remain a specialist topic in strategic management. Accordingly, industrial experts – when compared to other stakeholders – consider it to be less likely that every decision will be supported by ICT-based support systems.

**Example: Computer-Brain Interfaces**

Brainwave controllers are developing quickly and have recently become available on the market. Presently, most devices are used either in gaming and entertainment (e.g. to control objects’ directions during a computer game) or to support disabled and elderly people (to switch on lights, etc.) [56]. However, future technology might have the potential to enable humans to think about several aspects at once or to use computing power to enhance our brain capacities, thus augmenting our analytic capabilities to evaluate multiple scenarios [57].
In-depth group analysis for projection 15 reveals that academics’ expectations differ from those of the other experts. The participating academics assign a higher desirability to popular participation in futures research, yet they also believe it to be less probable and expect a lower impact than the other groups. These results match their high expectations for increasing efficiency and their comparatively low expectation for a revolution in ICT-based foresight. Thus, academics believe that advancements will be made incrementally rather than as major paradigm shifts.

**Example: Climateprediction.net**

The climateprediction.net project aims at testing climate model sensitivity to small changes in underlying data approximations. Instead of one supercomputer, the project relies on using idle capacities of personal computers to create more computing power. Thereby, the climate models can be conducted further than previously possible so that many different scenarios can be evaluated. Thus, the exact effects of different factors in climate change can be calculated. Currently, more than 35,000 private hosts share their enthusiasm for the project by granting access to their computers. Meanwhile, more than 127,000 model years have been run on the system [58]. In 2010, the parallel project weatherathome.net was launched to calculate climate change effects on local weather conditions for the first time.
Implications for Projections 12 to 15 for Theme #4: Implications and Stakeholders

The changing practices in ICT-based foresight are most commonly associated with three aspects by the experts: better accessibility of foresight and futures data; improved communicative features that allow coordination among experts, departments and stakeholders; and enhanced ability to assess and combine data from different areas and research fields. These features prompt many Delphi participants to envision more efficient and widely used foresight methods in the future. As a consequence, more companies could utilise competitive advantages associated with foresight: market developments could be anticipated and consumer behaviour better understood.

The routine support of strategic decision making with ICT-based foresight tools might also overcome or reduce decision makers’ false assumptions and biases, such as overconfidence, as well as external factors, such as vested interests. This would increase the transparency and objectivity of such decisions. Furthermore, efficient tools could also make more time available for decision makers to conduct creative tasks and, in combination with their quantitative capabilities, provide the opportunity to address complex challenges.

In general, the Delphi participants expect futures research to be supported by ICT as a standard practice and contribute to reliable and sustainable decision making. These advantages could be magnified if futures research becomes popular in all parts of society. If stakeholders agree to participate in foresight exercises, other people might be attracted to provide personal data for foresight purposes: more human capital would be attracted to a popular profession – even if some of the attracted practitioners might be less serious. Public pressure might even increase implementation of corporate and public foresight activities, offsetting concerns that the conservative mindset of many decision makers could be a barrier to implementation and that organisations are often reluctant to change.

However, popularity should not be the main objective of foresight, rather the quality of decisions resulting from foresight. In this respect, the experts fear that routine ICT support might induce false certainty or could discourage managers from considering uncertain and impactful events due to computer-generated advice. The consensus is that creative thinking cannot be substituted by sophisticated tools.

Furthermore, the experts worry about the diversity and general developments of foresight methodology if ICT-based foresight tools are implemented broadly. Many assume that certain tools might streamline the processes of foresight exercises, thereby limiting diversity and eliminating the sustainable advantage of best practice approaches. The reliance on ICT tools might also curb the interest in developing non-ICT methods, ultimately stalling the development of futures research methodology. However, it is likewise argued that the success of certain ICT tools – in financial and quality terms – would lead to a self-reinforcing process: more resources and research would be committed to ICT-based foresight research and consequently result in improved tools and methods.

Key Findings and Recommendations

ICT will likely change the practice of futures research considerably. Features such as collaboration, holistic thinking, and creativity will become more important in strategic decision making. Organisations should design their practices and train personnel accordingly without neglecting the importance of face-to-face interaction. The gradual popularity of foresight will attract talented employees to incorporate foresight in their work or expect foresight to be an essential element of their work. However, organisations should strictly use ICT tools to support decisions and not allow the creative and innovative spirit to become complacent.

For consultancies, the trend toward greater acceptance of ICT will promote the application of ICT tools during foresight projects. Due to rising demand, the investment in tool development will most likely be worthwhile, but only high-quality tools will be successful. Therefore, tools should be developed in accordance with users’ concerns and their application in decision making should be clear in order to provide sufficient accountability. Multiple decisions should be projected along with each decision’s consequences to eliminate simplified solutions to complex problems. Considering the increase in foresight awareness and popularity, it would be suitable to include crowd sourcing in foresight practice.
Extreme Scenarios – Extending the Outlook of the Future

Scenarios foster a culture of curiosity and create an atmosphere of creative thinking. More extreme scenarios, generated by the scenario-axes logic, venture beyond the boundaries of what is already known and assumed, and introduce dramatic developments, which could possibly occur in the future. In order to develop these extreme scenarios, we selected two dimensions which were of particular relevance to the Delphi panel: the type of expertise which would be relied on in the future (group or individual) and the level of ICT sophistication (low to high). For the first dimension, Projections 6, 7, and 15 addressed the inclusion of the public and external shareholders (wisdom of the crowds) in foresight as opposed to individual expert wisdom. Furthermore, all three projections had an estimated probability of occurrence of approximately 50%, indicating the potential for extreme divergence. Similarly, the World Economic Forum’s report on the scenario study “Digital Ecosystem 2015” differentiated between “industry-led” and “organic- and community-led” value creation in ICT [59]. For the second dimension, the overall driver of the study was selected: the level of sophistication of ICT tools in 2020. ICT development was addressed most notably in projections 5, 10, 11, and 12. Whereas projection 12 surveyed the overall expectation about the development of ICT in futures research, the other three projections projected different levels of sophistication for specific solutions. The two dimensions were plotted against two axes with extreme poles. Four extreme scenarios were derived from this as shown in Figure 1.
Based on two axes, we label the scenarios as follows:

1) Domain of ICT Consultants
2) Society of Futurists
3) App World / Commoditization of Futures Research
4) Sphere of Day-to-Day Challenges

These extreme scenarios may seem odd to some people. However, by imagining such scenarios, decision makers can better prepare themselves for the future by taking proactive action to either counteract possible negative side effects or to take advantage of lucrative opportunities accordingly. It is also possible that a mixture of all of these scenarios or only certain elements of each scenario occur. Time will tell what the future holds.
Scenario I: Domain of ICT Consultants in 2020

Added Value
Futures research relies heavily on experts’ knowledge. In contrast, wisdom of the crowds is rarely applied. Due to its lack of specificity and concerns about intellectual property rights profit-seeking firms consider it to be uninteresting. Since many experts and businesses conduct futures research, input is abundant. Consequently, futures research is most prevalent for business and economic issues.

Integration
Market pull has led to many new ICT tools being developed by consultancies. These have been designed to be interconnected and most consultancies offer a complete portfolio of tools for all stages of the foresight process: foresight exercises can be conducted with different tools for different phases using the same data but customers have to remain loyal to one provider for the entire procedure.

Individualisation
Standard ICT tools are provided but can be adapted to the user’s needs at extra cost. Clients often have software packages customised to their needs and take advantage of the comprehensive portfolios of most consultancies.

Technology
Development of ICT-based foresight tools has progressed considerably. Moore’s law, the observation that chip performance doubles roughly every two years, has held true: the tools are able to process extremely large amounts of data. Complex model calculation can be used to more reliably determine desirable outcomes in future developments. Consequently, all cutting-edge enterprises rely on ICT-based decision support and use ICT-based tools for scenario transfer.

Stakeholders
Whereas foresight still plays a negligible role in society, it has vastly gained in importance for business purposes. Successful foresight consultancies have developed into software providers. Smaller consultancies have become foresight tool consultants.

Data Quality
Although the lack of societal hype for futures research only broadened the data basis marginally, the majority of additional input stems from experts and is fundamentally researched. The high sophistication of ICT tools produces high quality data and specifically quantitative forecast data. Data manipulation is not an issue due to the proprietary nature of the tools.
Scenario Path to the Domain of ICT Consultants

2014
A successful foresight consultancy has started to offer a complete package of ICT-based foresight tools. Clients select elements of the offerings according to their needs. In the aftermath, market demand for ICT-based foresight tools increases strongly.

2016
A large multinational technology firm announces it has successfully disseminated its ICT-based foresight system to all subsidiaries and departments around the globe.

2017
A prominent law suit, where the largest provider of ICT-based foresight tools charged smaller competitors with patent-related misconduct, is settled.

2019
After conducting numerous pilot projects, the Chinese government introduces an institutionalised ICT-based foresight initiative.
Scenario II: Society of Futurists in 2020

Added Value
Futures research has become popular; the search for a sustainable world is the predominant global goal. The accessibility of ICT-based foresight tools means that almost everyone has the opportunity to contribute their own opinions and wishes in foresight activities. Tools are readily available on the Internet and modern algorithms and semantic databases allow for vast amounts of data to be queried. As a consequence, expert knowledge is merely one source of information among many others.

Integration
Highly integrated tools adhere to international quality standards. The most widely used tool-suite is open-source based. It contains a vast database for web content mining and provides a multitude of analytic tools, such as scenario software, workshop spaces, and various complex models. Due to similar data structures, transferring data, results, or users from one suite to another does not pose problems.

Individualisation
Since many individuals engage in ‘recreational’ foresight, most of the tools can be adapted according to personal needs. ICT-based foresight tools have become a commodity, which indicates that margins for professional providers are low. Expert customisation of business foresight tools is a separate industry.

Technology
Major technological advancements have resulted from a collaborative open-source approach that introduced widely accepted semantic standards for Internet-based applications and from a joint scientific initiative to improve calculations of complex models. Society’s willingness to share ideas has led to torrential data input in software. Consequently, crowd-sourcing applications can reach their full potential. Artificial intelligence challenges have become the subject of ethical discourse in democratic countries.

Stakeholders
Almost every company practices foresight to some degree, and many pursue open foresight approaches. However, the omnipresence of foresight tools and lack of proprietary information means that engaging in foresight can only provide marginal competitive advantages for companies. As a result, ICT tools have replaced the work of foresight consultancies. Foresight experts, who are specialised in specific areas and use non-ICT-based approaches, are employed for special projects. Foresight has also become a priority for policy makers. ICT-based tools are used to convey popular wishes and expectations to governments and the collaborative nature of the tools facilitates collaboration across national borders. As a result, many approaches to solve the most important international problems – climate change, poverty, regional environmental issues, and sustainable global financial stability – are being conducted. Overall, the sustainability of most decisions has been greatly improved.

Data Quality
Data quality has improved due to semantic standards and international standards. However, the popularity of futures research makes foresight tools powerful instruments to shape public opinion. Thus, manipulation is attractive. Even though effects are mitigated by the sheer number of vigilant eyes in the process, this risk and the importance of foresight in policy forming processes have led to increasing surveillance of the foresight community.
**Scenario Path to the Society of Futurists**

**2014**
The first Fortune 500 company uses a social media-based foresight method to generate data from the wisdom of the crowds for its long-term strategy development.

**2015**
All current climate development models are integrated into one gigantic open-source model.

**2017**
A regional election in Germany is conducted remotely. Voters can express their opinions and wishes concerning important policy issues directly in the ballot.

**2019**
The majority of the world’s most important companies practice open foresight. Companies that do not practice it have a competitive disadvantage.
Scenario III: Commoditization of Futures Research (App World) in 2020

Added Value
Futures studies have made their way into society so that enterprises employ open innovation and crowd-sourcing for their strategic foresight activities. Many competing software solutions exist – from costly versions for business purposes to free crowd-sourcing applications on social media platforms. However, the vagueness of many results and scenarios limits the value-added in subsequent decisions. Futures data has not made much qualitative progress and complex model calculations have not been substantially improved. Moreover, standards have not been established.

Individualisation
Since result-oriented and content-related innovations are scarce a great deal of effort is dedicated to individualisation. Especially in project-based foresight practice, consultancies customise software according to the companies’ needs. The adaptation of open-source software to ongoing business processes is difficult.

Technology
Progress in ICT has slowed since 2013. Moore’s law has not held true and thus computing power – although it has grown – is not up to the level expected. Additional problems, for example slow bandwidth and shortages of human capital, complicate meaningful progress in advanced ICT tools. Data mining is still hindered by a lack of semantic standards and research in calculating complex models has come to a halt.

Stakeholders
In light of the growing popularity of futures research, corporate foresight has somewhat grown in importance, resulting in a slight increase in demand for foresight tools. However, open-source or free-of-charge solutions make many companies shy away from high cost tools, while others practice open foresight. Foresight practitioners are thus confronted with low margins, while the value added in proprietary solutions has to be high in order to find a market. In government policy, social media-based applications are monitored in order to gain a sense of the population’s expectations. For some projects, attempts at involving stakeholders via ICT-based foresight tools are being made.

Data Quality
The mix of futures research’s popularity, crowd-sourcing approaches, and the general lack of standards has resulted in a confusing abundance of future-related data. This makes manipulation of data attractive, while the lack of an authoritative body and the qualitative nature of the data make detection of manipulation difficult. The data’s low quality is a major reason why little progress has been achieved in foresight accuracy.
Scenario Path to the App World

2014
After a series of high-profile newspaper articles and news reports, foresight practitioners accurately warn about social upheaval in China and a water crisis in Eastern Europe.

2015
One of the largest IT companies sets up an open foresight project but runs into legal trouble. Consequently, foresight practice is only used for low importance decisions.

2016
Popular foresight apps are now a standard feature on most personal electronic devices but standardisation and compatibility have not been achieved.

2019
A collaboratively developed scenario simulation of future living in the UK is damaged by the use of manipulated data or proves to be unsubstantiated due to manipulated data.
Scenario IV: Sphere of Day-to-Day Challenges in 2020

Added Value
Futures research remains a niche topic without popular interest. The number of companies engaging in corporate foresight has remained the same. Companies engaging in foresight practices are marginally successful and have not yet achieved major breakthroughs. Corporate foresight is predominantly outsourced to consultancies that implement workshops and similar creative sessions; ICT tools are rarely used. Participants are mostly experts from the departments involved in the particular study.

Individualisation
Foresight is project-based. Consultancies tailor the projects according to the companies’ needs. However, methods are often rigid because exchange among different consultancies is limited. Employees’ personal ICT devices cannot be incorporated because business is conducted with non-ICT procedures.

Integration
Foresight projects are usually not related. Data input primarily consists of ad hoc knowledge from participating experts with some desk research to provide background information. The consultancies implementing the projects compete against each other and thus do not share detailed knowledge. Scientific research in ICT-based methods of futures studies has been greatly reduced.

Technology
Computer power has improved at a lower rate than expected – complex modelling and data mining haven proven unsuccessful. Even in other areas, such as environmental technology, transportation, and communication, optimistic progress has waned. Consequently, popular trust in technology has suffered greatly.

Stakeholders
The public did not become interested in foresight, let alone ICT-based foresight tools. The fact that many optimistic scenarios related to technology promoted wrong expectations and images is considered to be evidence that the discipline is of lower value. Overall, companies have become more short-term focused than before. Lacking technological development, they have trouble increasing productivity. Consequently, competition from emerging markets – where companies are still profitable – is forcing them to initiate cost-cutting measures. Costly ICT-based foresight tools are not a priority. Futures research efforts in academia are suffering from less public funding. For the same reasons as the public, governments are sceptical towards futures research. Accordingly, priorities are set elsewhere.

Data Quality
Data quality has not changed much since 2013. Workshops rely on expert knowledge, statistical data from national administrations, and a limited number of Delphi or other foresight studies. Crowd-sourcing approaches are generally not part of the data input. Availability of plausible data is as much a problem as its interpretation. Manipulation of data is not an issue.
It becomes clear that Moore’s law will no longer hold true. Technological progress begins to stall in many areas. This reflects negatively on the futures research discipline.

2016
In a TV challenge, three experts from different fields are more accurate in their predictions than the most advanced super computer array for ICT-based futures studies.

2017
A multi-billion dollar ICT research project designed to simulate the world by a very complex model calculation spectacularly fails.

2019
Several companies offering distinctly non-digital foresight products and services report double-digit growth rates, while the demand for foresight support systems has dropped considerably.
Opportunity Radar – Roadmap to the Future

This section investigates promising opportunities for governments, the public, consultancies, corporate entities, and academia in ICT-based futures research. The Opportunity Radar is the subjective outcome of several futures workshops, based on this survey’s results, as described in the previous sections. In order to provide a tool which supports decision making, the radar presents possible opportunities, with different degrees of innovativeness, to certain target groups. Several prospects are already close to implementation, while others remain visions of potential breakthroughs.

Figure 2: Opportunity Radar for ICT-Based Futures Research
Foresight Consultancies / Tool Developers

Integrated Foresight Tools (2013)
The global market for ICT generates €2.4 trillion [60]. Until now, only a small portion of this amount is invested in ICT-based foresight tools. However, in the future, this situation is likely to change (on a moderate scale). Consequently, integrated Foresight Support Systems (FSS) could become a growing lucrative market. Thus, an early start in creating such software packages could result in a significant first mover advantage. Early development of innovation, such as pioneering standards in software coding or semantic structure, often results in reputational benefits.

Foresight Communication (2014)
ICT significantly facilitates communication in foresight. However, many experts complain that ICT tools do not support face-to-face interaction with other people. Thus, the inclusion of video conferencing features in foresight tools would be helpful solutions [61]. Such features could motivate the purchase of ICT-based foresight tools.

Scenario Transfer Advisory (2014)
The possibility exists that much of the work futures consultancies provide to their clients today will incrementally be substituted by ICT-based tools. Consultancies could offer a complementary service to clients to support them in actually implementing the imparted foresight knowledge efficiently. In addition to drawing the right strategic conclusions, this service would also include communicating foresight activity outcomes among company staff, constantly verifying scenarios in comparison to reality, and scanning the environment for weak signals.

Foresight Apps (2015)
The results of this Delphi survey demonstrate that it seems probable that futures research will continue to gain in popularity in the general public. Thus, catering to individual consumers’ needs could potentially create a business opportunity. Applications could range from simulating or envisioning future scenarios of general-interest topics (with educational side-effects) to crowd-based approaches for solving futures-related challenges in the immediate social environment. Given the current ICT trends, it would seem suitable to develop these tools as apps for smartphones and tablet PCs.

Crowd Motivation (2015)
Futures studies will potentially take advantage of the wisdom of the crowds in the future. However, it remains open as to how people will contribute their knowledge. Game-like business applications might be a solution [62]. Therefore, eliciting knowledge from the general public might become the main challenge in ICT-based futures research. Incentivisation schemes to encourage participation in wisdom of the crowds surveys could soon become a much sought after technology.

Brand Building (2019)
The IBM brand is worth more than $100 billion [63] and is the perfect example of how complex software solutions can be used for brand building. As of today, foresight consultancies are primarily small firms in a small market. Experts do not expect this to change by 2020. At some point, consolidation of the market will be inevitable. Those companies that have been able to establish themselves as brands on the market will have a competitive edge. Therefore, foresight consultancies should strive to develop their reputations, for instance as being particularly innovative or reliable, as soon as possible.

Easy Tools (2020)
The general expectation among the surveyed experts is that ICT tools will continue to evolve rapidly. However, at the data-gathering level, most of the creative and interpretative work will still have to be performed by the users. There is widespread need for software that is not only universally applicable and rich in strategic foresight tools, but also easy to use and to maintain. Most importantly, such software should perform the explanatory and interpretative work consultancies specialise in today.
**Academia**

**Standard Semantics (2014)**
The semantic web makes digital information comprehensible to computers so that automatic intelligent linkages among websites are possible. Google, Microsoft and Yahoo boosted the development in this field [64]. As a result, increasing amounts of data from the Internet can be applied in ICT-based foresight tools. Wisdom of the crowd advantages can be realised on a larger scale and the standardisation could lead to a consolidation and integration of software packages. These advancements could also benefit ICT-based foresight, facilitate open foresight development, and possibly consolidate the consultancy market.

**Expert Directory (2014)**
Many of the advantages of ICT-based foresight tools can only be realised if suitable data sources and appropriate methods are used. Conducting a successful Delphi survey for example, requires the participation of the right experts, as do other qualitative and creative methods, such as (online) workshops. Identifying and contacting these experts constitutes a challenging and time-consuming endeavour. Building an expert database, which includes data such as the field of expertise, willingness to contribute, and contact information, as well as a clever mechanism for managing (and not overloading) these relations, could result in the competitive advantage of invested stakeholders.

**Complex Models (2018)**
The majority of the experts expect progress in modelling complex systems, yet the discussion of the projection clearly shows that this progress should only be incremental and slow. If improved data retrieval, larger computer power, and significantly better modelling could be achieved, the effects would be enormous. If used correctly, this would lead to more reliable decision making and a more sustainable society. Developers of such software would gain significant influence and could lead the next wave of innovative technological enterprises.

**Governments**

**Improved Opinion Polling (2015)**
Political decisions are always subject to public scrutiny and rely on popular consent. Many decisions adapt to input of constant popular polling. ICT-based foresight tools offer the opportunity to institutionalize polling by enabling people to voice their opinion through innovative measures. At the same time, the tools could be used to inform the public about advantages and disadvantages of certain policies. ICT technology thus enables the possible combination of polling with petitioning and could potentially be a driver in reforming the political system.

**Public Tools (2018)**
Politics and governments are among the areas that stand to benefit the most from ICT-based foresight tools. Open government approaches can be used to increase the transparency of administrative decisions and activities vis-à-vis the citizens [65]. ICT-based foresight tools could be used to involve citizens in assessments of possible decisions and could thus lead to a more direct democracy. The early development of respective tools could possibly open up a new market.

**Popular Decision Making (2019)**
According to experts taking part in a Delphi study about future uses of ICT in Germany [66], a sizeable proportion of the participants estimated that online tools would strengthen direct democracy in Germany in 2020. They also perceived this development to be stronger in other countries. ICT based foresight tools could play a major role in combining citizens’ opinions while educating the public about possible outcomes and consequences of decisions to be made.

**Political Early Warning Systems (2020)**
With enhanced sophistication of ICT-based foresight tools, governments should install early warning systems for global and complex challenges. This could involve a combination of tracking quantitative data, qualitatively scanning developments, and monitoring scenario developments. The earlier challenges are detected, the easier it will be to adapt policies and fine-tune developments according to needs.
Industry

Intra-Company Collaboration (2013)
Presently, foresight activities in many companies are inadequate due to two factors: the amount of time required to become proficient in foresight tasks and the subsequent lack of penetration throughout the company: foresight workshops run a minimum of one day and afterwards only participants are able to implement the acquired know-how. This situation can be resolved by employing ICT tools in foresight methods. The results can be distributed to all relevant employees, where they can be compared and linked to applications in daily business procedures. Depending on the circumstances, ICT tools can also be used to split lengthy workshops or implement them in remote fashion.

Open Foresight Early Mover (2015)
Implementing open foresight early on seems to have two distinct advantages. (1) The stakeholders may not yet be committed to other companies’ open foresight programmes, and thus be more motivated and committed to continuous contribution. (2) Pioneering firms in open foresight are also able to tap into an unused pool of creativity. Early implementers of open foresight may gain competitive advantages before other firms acquire the same knowledge.

Foresight Learning Centre (2017)
Since foresight may have become a regular subject in academic curricula, establishing and sponsoring central competence centres could potentially facilitate further development of futures research methodology and ICT tools, as well as their proliferation throughout society. The specialised abilities of different stakeholders would complement each other and benefit all stakeholders invested in the academy. The institution could be directed by universities or think tanks and be based on knowledge databases, such as an “expert directory”.

Foresight Networking (2020)
Whereas in the short term, ICT-based foresight tools for future personal, corporate, and public challenges will probably remain distinct from each other, in the long term, linkages among the systems could further enhance data quality for each system. Valuable foresight data taken from individual corporate planning data could be transferred among companies, making it easier to make accurate estimations of future quantities, developments, and acceptance levels of certain actions. Governments could derive desirability scores for planned political actions. The business world might be able to better coordinate required capabilities and human capital planning; collaborative industrial policies and corporate innovation could be more closely implemented. There is enormous potential for resource savings and efficiency gains in foresight networking.

Population

Personal Scenarios (2016)
If the popularity of foresight continues to increase, people could start to rely on futures research methodology to plan their personal lives – be it career advancement, selecting geographical locations, or consumption and financial planning. Software could enable people to calculate scenarios involving factors from their environment and compare how potentially life changing decisions could develop under different circumstances.

Personal Mapping (2020)
Beyond personal scenarios, apps could become a constant companion in personal life planning. By connecting to social media profiles, scenarios could be continuously compared to real progress. News outlets and connected devices of important partners, friends and relatives could contribute to the inflow of data. Sophisticated tools could highlight opportunities, find relevant information, and inform the user about risks.
Wildcards – Thinking Out-of-the-Box

Unforeseeable events take place every day. In this section, possible events are presented that could severely affect the way futures studies are performed. Thereby, they support in broadening the perspective to test and challenge one’s own assumptions.

Only negligible Progress is achieved in the Development of ICT-based Foresight Tools by 2020

Most foresight work today is already based on some sort of ICT tool – statistical packages calculating the extrapolation of trends, the consultation of trend databases, scenario planning software, or the implementation of foresight markets. However, many experts believe that Moore’s law will discontinue before 2020 [66]. Consequently, a lack of further development could potentially discredit foresight in the eyes of many managers, who perceive foresight as a promising method for strategic planning. Therefore, if the development of ICT-based foresight tools stagnates, the importance of strategic foresight would quickly wane.

Protest against ICT and Attacks on Central Servers

ICT and its influence on everyday life are steadily becoming more controversial. In many respects, having access to ICT devices and actively using them, will be essential to take part in public and professional life. However, this situation contributes to the power of dominating market firms and potentially leaves many people behind: those who are not capable of using such devices and those who do not consent to using them. The pressure and dominance of ICT could thus provoke resentment which might result in widespread protest, similar to the Occupy Wall Street Movement that led to worldwide protests against another dominating industry: finance [67]. If the situation escalates, physical attacks could be made on central servers, resulting in the breakdown of ICT-based foresight infrastructure and data loss.
The emergence of real AI would obviously have massive consequences for ICT-based futures research (as well as for society as a whole). If human-like creativity and the quantitative skills of computers could be united in one device, completely new ways of evaluating futures-relevant data would be possible. Combined with powerful data mining and web mining functions, computer-generated forecasting could become more comprehensive and detailed. In his book “The Singularity is Near” Ray Kurzweil estimates that computers will surpass humans as the smartest beings by 2045. The emergence of true artificial intelligence, indicated by passing the Turing test (a human cannot reliably distinguish between a human and a machine through conversation alone), is predicted for 2029 by Kurzweil. For 2020 (the time horizon of this study), the author foresees machines with computing capacities equivalent to the human brain [68].

Worldwide Censorship of Internet

Economically successful state capitalism without political freedom might increase around the world [69]. Many countries in Asia, Africa, and Latin America choose state capitalism as a form of government. If the Western world feels threatened by this development, Western governments might introduce certain features of such systems to their countries, for instance curbing the freedom of information on the Internet. However, censoring websites and potential governmental monitoring of online tools on a massive scale would lower the reliability of ICT-based foresight tools. If the Internet was censored, companies would stop using it as a means of communication.
Offline is Chic

Presently, there are already some powerful and important persons, who have ceased using cellular and smart phones. The reasons for doing so are manifold, ranging from trying to train one’s own memory, to attempting to instil a conversational culture in the company, to shifting downwards and making one’s self less available [70]. While most of these people probably still use the Internet and have employees equipped with electronic devices, due to concerns about rights to privacy, the offline trend is feasible. If drastic reductions were made to online time, developments in ICT-based futures research would come to a standstill because important input from trendsetters could not be compiled.

Cyber War breaks out

Hacker attacks could entail devastating security threats to countries. Many countries have established agencies to detect and hinder cyber attacks and Internet crimes. Even infrastructures of countries have been subject to coordinated cyber attacks. As a consequence, the United States has declared their digital infrastructure to be a strategic national asset [71]. A full-blown cyber war, as described in Richard Clarke’s book Cyber War [72] – including electricity failures, pipeline explosions, food shortages, and communication failures – would undoubtedly have severe consequences for ICT-based futures research. The threat of manipulated data would rise exponentially, government surveillance of all Internet activity would massively increase, and cross-border communication would be severely hampered. Public trust in ICT-based or Internet-derived information would be drastically reduced, thus making many ICT-based foresight tools less valuable.
Methodology – From Delphi Survey to Scenarios

Real-Time Delphi Methodology

This study employed a foresight methodology called real-time Delphi procedure. The conventional Delphi procedure is conducted anonymously, in written form, over many rounds or stages. Feedback of group opinion is provided to all participants only after each round. Our real-time Delphi method was organised as an Internet-based survey which provides participants with immediate feedback of group results. Thereby, the validity of results is improved and the entire process is easier and more interesting for the surveyed experts [4, 5].

Based on extensive desk research, expert consultation, and workshop sessions, the project team developed 15 key projections concerning the future of ICT-based futures research. Participants of the survey were asked to rate these projections according to probability of occurrence (0-100 percent), impact on the foresight market/community (5-point-Likert scale), and desirability (5-point-Likert scale) as well as to optionally provide quantitative information (reasons) for their answers. After the first round of assessment was completed, the statistical group opinion of all participants was calculated immediately and made available to participants for the second round of analysis. Each participant had access to peers’ evaluations of projections. Based on this data, initial evaluations could be re-assessed and adapted. After completing the questionnaire, experts could access the Delphi portal via their personalized link at any time. The final results of the real-time Delphi survey provided the framework for further analyses in this study.

Delphi Panel Selection

The objective of Delphi studies is not to obtain a representative sample of general public opinion. Rather, Delphi research aims at obtaining expert opinion. Therefore, the expert panel included futurists and thought leaders from all over the world. Overall, 177 experts participated. Participants were selected based on (research) background, work experience, as well as internal and external functions in organisations. The experts were recruited in a multistage process incorporating the most influential experts, who were identified based on their publications, conference contributions, and memberships in top futurist networks. A selection of important sources for expert invitations is shown in Figure 3.

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<th>Networks</th>
<th>Conferences</th>
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<tr>
<td>• Club of Rome</td>
<td>• European Futurist Conference</td>
<td>• Editorial Boards of Long Range Planning, Strategic Management Journal, Technological Forecasting &amp; Social Change, Foresight, Futures</td>
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<tr>
<td>• Global Business Network</td>
<td>• Finland Futures Conference</td>
<td>• Members of the “100 Most Influential Futurists” List</td>
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<td>• Millennium Project</td>
<td>• FTA Conference Séville</td>
<td>• ICT Experts from “The Futurist Directory” [74], Singularity University</td>
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<td>• German Network Futures Research</td>
<td>• Stockholm Futures Conference</td>
<td>• WorldFuture Conference</td>
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Figure 3: Selected Sources of Expert Recruitment
This study aimed to present a comprehensive worldwide perspective. Delphi panel experts were based in 38 different countries, ensuring a balanced view of the future of ICT-based futures research in 2020 (see Figure 4).

Countries: Argentina, Australia, Austria, Azerbaijan, Belgium, Brasil, Canada, Chile, China, Denmark, Estonia, Finland, France, Germany, Greece, India, Iran, Israel, Italy, Japan, Korea, Kuwait, Mexico, Netherlands, Singapore, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Tanzania, Thailand, Turkey, UAE, UK, USA, Venezuela

Figure 4: Experts’ Countries of Origin

Experts stemmed from five specialist areas: academia, applied research, industry, consultancies, and governmental and business associations. The distribution of experts among the five groups is depicted in Figure 5.
Delphi Statistics

The Delphi survey was highly dynamic. During the eight-week survey process, each participant took part in 2.9 Delphi rounds on average. The group discussion included 2,082 written arguments, which equals 11.8 comments per expert. The comments were coded into 454 different arguments. These arguments constituted the basis for all conclusions and discussions in the present study. The high amount of comments underscores the quality of data and provides a sufficient basis for further scenario writing.

Overview of Projections

EP=Estimated Probability; I=Impact; D=Desirability; IQR=Interquartile Range; CV=Convergence (% decrease in standard deviation)

Measures of C=Consensus (interquartile range <= 25); dissent (interquartile range > 25)

<table>
<thead>
<tr>
<th>Projection for 2020</th>
<th>EP</th>
<th>I</th>
<th>D</th>
<th>IQR</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020: The efficiency of future-oriented planning processes could be significantly enhanced by the application of ICT-based foresight tools.</td>
<td>65.2%</td>
<td>3.6</td>
<td>3.7</td>
<td>30</td>
<td>-7.6%</td>
</tr>
<tr>
<td>2020: The quality of foresight data for future-oriented planning could be significantly enhanced by the application of ICT-based foresight tools.</td>
<td>63.6%</td>
<td>3.6</td>
<td>4.0</td>
<td>30</td>
<td>-2.4%</td>
</tr>
<tr>
<td>2020: The reliance on ICT-based futures research has increased the amount of manipulated future-relevant data.</td>
<td>61.4%</td>
<td>3.5</td>
<td>2.1</td>
<td>30</td>
<td>-4.9%</td>
</tr>
<tr>
<td>2020: Internationally recognised quality standards have been established in futures research.</td>
<td>45.1%</td>
<td>3.2</td>
<td>3.6</td>
<td>30</td>
<td>-4.4%</td>
</tr>
<tr>
<td>2020: An intelligent interconnection of ICT-based foresight tools (e.g. integrated software packages, harmonization of interfaces) allows for higher quality in future-oriented planning processes than individual ICT-based foresight applications.</td>
<td>62.4%</td>
<td>3.6</td>
<td>3.8</td>
<td>30</td>
<td>-1.9%</td>
</tr>
<tr>
<td>2020: The reliance on individual expert knowledge has diminished, while the trust in group wisdom and collective intelligence is emerging.</td>
<td>53.3%</td>
<td>3.4</td>
<td>3.0</td>
<td>25</td>
<td>-4.9%</td>
</tr>
<tr>
<td>2020: Open foresight has become standard practice in business.</td>
<td>49.0%</td>
<td>3.6</td>
<td>3.7</td>
<td>20</td>
<td>-6.9%</td>
</tr>
<tr>
<td>2020: ICT-based foresight tools have largely displaced the market for futures consultancy services.</td>
<td>30.4%</td>
<td>3.2</td>
<td>2.2</td>
<td>20</td>
<td>-17.3%</td>
</tr>
<tr>
<td>2020: Wise interpretation of futures-oriented knowledge, rather than its availability, has become the key challenge in the field of futures studies.</td>
<td>78.5%</td>
<td>3.8</td>
<td>4.1</td>
<td>20</td>
<td>-10.7%</td>
</tr>
<tr>
<td>2020: ICT solutions have improved the ability to anticipate future developments of complex systems.</td>
<td>55.2%</td>
<td>3.7</td>
<td>4.0</td>
<td>30</td>
<td>-5.7%</td>
</tr>
<tr>
<td>2020: ICT-based foresight tools have eliminated problems of scenario transfer into strategy.</td>
<td>32.2%</td>
<td>3.3</td>
<td>3.2</td>
<td>25</td>
<td>-8.1%</td>
</tr>
<tr>
<td>2020: Information and communication technology (ICT) has revolutionized the practice of futures research.</td>
<td>63.4%</td>
<td>3.7</td>
<td>3.7</td>
<td>30</td>
<td>-7.9%</td>
</tr>
<tr>
<td>2020: The demand for ICT solutions in futures studies has grown significantly over the past decade.</td>
<td>72.0%</td>
<td>3.7</td>
<td>3.6</td>
<td>20</td>
<td>-6.8%</td>
</tr>
<tr>
<td>2020: Strategic decision making without support of ICT-based foresight tools has become an exception in the business context.</td>
<td>51.1%</td>
<td>3.4</td>
<td>3.2</td>
<td>35</td>
<td>-2.7%</td>
</tr>
<tr>
<td>2020: Futures studies have become very popular due to innovative ICT applications (e.g. web-based, real-time, social media).</td>
<td>56.2%</td>
<td>3.6</td>
<td>3.7</td>
<td>30</td>
<td>-6.0%</td>
</tr>
</tbody>
</table>

Figure 6: Delphi Projections and Results
Bias Testing

Since it has been proven that people tend to overestimate probabilities of occurrence for (un)desirable events and developments, a test for a desirability bias was conducted [75]. Results of the test are presented in Figure 7. The adjusted values are not necessarily more accurate than the original values; they merely constitute a broader basis for interpretation of the Delphi results. Very significant adjustments were indicated in the main text of the study. Specific attention is given to one projection (10), where the adjustment changes the probability from more than 50% to less than 50%.

<table>
<thead>
<tr>
<th>Projection</th>
<th>Estimated Probability</th>
<th>Bias potential (percentage points)</th>
<th>Adjusted Probability</th>
<th>Desirability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Planning Efficiency</td>
<td>65.2%</td>
<td>+6.0</td>
<td>59.2%</td>
<td>3.7</td>
</tr>
<tr>
<td>2 Foresight Data Quality</td>
<td>63.6%</td>
<td>+8.0</td>
<td>55.6%</td>
<td>4.0</td>
</tr>
<tr>
<td>3 Data Manipulation</td>
<td>61.4%</td>
<td>-11.0</td>
<td>71.5%</td>
<td>2.1</td>
</tr>
<tr>
<td>4 International Standards</td>
<td>45.1%</td>
<td>+4.3</td>
<td>40.9%</td>
<td>3.6</td>
</tr>
<tr>
<td>5 Integration of ICT tools</td>
<td>62.4%</td>
<td>+6.2</td>
<td>56.3%</td>
<td>3.8</td>
</tr>
<tr>
<td>6 Group Wisdom</td>
<td>53.3%</td>
<td>-0.9</td>
<td>54.2%</td>
<td>3.0</td>
</tr>
<tr>
<td>7 Open Foresight</td>
<td>49.0%</td>
<td>+5.1</td>
<td>44.0%</td>
<td>3.7</td>
</tr>
<tr>
<td>8 Consultancy Market</td>
<td>30.4%</td>
<td>-9.3</td>
<td>39.7%</td>
<td>2.2</td>
</tr>
<tr>
<td>9 Data Interpretation</td>
<td>78.5%</td>
<td>+9.0</td>
<td>69.3%</td>
<td>4.1</td>
</tr>
<tr>
<td>10 Anticipation of Complex Systems</td>
<td>55.2%</td>
<td>+7.7</td>
<td>47.6%</td>
<td>4.0</td>
</tr>
<tr>
<td>11 Scenario Transfer</td>
<td>32.2%</td>
<td>+1.2</td>
<td>31.6%</td>
<td>3.2</td>
</tr>
<tr>
<td>12 Practice of Futures Research</td>
<td>63.4%</td>
<td>+5.4</td>
<td>57.8%</td>
<td>3.7</td>
</tr>
<tr>
<td>13 Demand Increase</td>
<td>72.0%</td>
<td>+5.1</td>
<td>67.0%</td>
<td>3.6</td>
</tr>
<tr>
<td>14 Strategic Decision Making</td>
<td>51.1%</td>
<td>+0.9</td>
<td>50.1%</td>
<td>3.2</td>
</tr>
<tr>
<td>15 Futures Studies Popularity</td>
<td>56.2%</td>
<td>+5.7</td>
<td>50.6%</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Figure 7: Results for Desirability Test

We also checked for non-response bias and compared the answers of early respondents with those of late respondents, assuming that late respondents were more reluctant to contribute. In order to test for the non-response bias, we used Kruskall-Wallis one-way analysis of variance. For the majority of projections, no significant bias could be detected. However, the few significant results reveal a slight overly optimistic behaviour due to respondents’ enthusiasm for ICT.
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The Institute for Futures Studies and Knowledge Management (IFK) is an academic think tank at EBS Business School, Germany. Under the direction of Dr. Heiko A. von der Gracht, the Institute conducts foresight studies in order to support companies and governmental decision makers in developing long-term strategies. The Institute focuses on systematic, scientifically grounded futures research. The primary objective is to generate futures knowledge for decision processes in government, business, and economics as well as to research innovative methods in future management. As a university research institute, it follows strict scientific standards and has access to a global network of universities and businesses. Within the scope of contract research, the Institute collaborates with partners in three main areas: Strategic Guidance, Competitive Intelligence, and Community Building.

The Leading-Edge Cluster Competition is a flagship of the high tech strategy for Germany: Under the slogan “Germany’s Leading-Edge Clusters – More Innovation, More Growth, More Employment” the competition was launched in August 2007 by the Federal Ministry of Education and Research. As one of the selected leading-edge clusters, the “EffizienzCluster LogistikRuhr” develops decentralized and autonomous logistics services along the entire value chain. Seven subtopics were strategically developed by the Logistics Cluster and reflect the main innovation areas of its endeavours.

Over the next few years, a multitude of projects will be conducted to create and test solutions for the partners along the value chain. One of these collaborative projects is the Competitiveness Monitor (project reference number: 01IC10L18 A), which addresses the challenge of strategic foresight. As a result of the project, a prototype of a collaborative online platform will be developed that combines four foresight tools in a Foresight Support System. The four diverse partners: Bayer MaterialScience, KPMG AG Wirtschaftsprüfungsgesellschaft, dilotec and EBS Business School are directly involved in the Competitiveness Monitor (CoMo) project. Their collaboration ensures high levels of scientific rigour and industry relevance. CoMo is designed as a future-oriented IT platform where science, business, and governmental partners of the cluster collaborate to ensure sustainable competitive advantage for all stakeholders.