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Challenging the Future.
Implications of the Horizon Scan 2050 for the Dutch Top-Industry Innovation Policy

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Abstract

The 'Horizon Scan 2050'-project identified so-called 'Signals for Change', i.e. developments that might affect the existing visions on the Grand (Societal) Challenges that the Dutch society faces. Using a long time horizon, various developments within societal domains were examined for the signals. The method used was a combination of analyzing signals from different sources and elaborating them in a creative and interactive manner into inspiring images of the future. To determine the possible impact of the results of 'Horizon Scan 2050', we compared the outcomes of the study to the current Dutch innovation policy, which focuses on supporting the so-called Top Industries. The overall impression is that the choice of Top-Industries is more a reflection of the current competencies of the Dutch economy than it is of its future potential, that High-Tech and Life Sciences and Health are the most robust (future-proof) Top-Industries, and that the Creative industry is a promising newcomer.

Keywords: Foresight, Innovation policy

Introduction

Technological, social, economic, and political changes not only happen faster but they are also becoming ever more entwined. A foresight study that wants to map the potential consequences of that will, therefore, adopts both a long and a wide perspective. Not only to satisfy the curiosity about the future, but also to give politicians, administrators and managers a way to deal with these dynamics. From this motivation, the Netherlands Study Centre for Technology Trends (STT) has set up a future study called *Horizon Scan 2050*, in which both a broad perspective and a long perspective (2050) have been chosen (Scheerder et al., 2014).

Horizon scanning is seen as a separate method for exploring possible futures. The OECD defines it as "a technique for detecting early signs of potentially important developments through a systematic examination of potential threats and opportunities, with emphasis on new technology and its effects on the issue at hand" (OECD, 2007). The definition of Van Rij also emphasizes the early detection of change and also considers it as a mean "to improve the robustness of policies and to identify gaps in the knowledge agenda" (Van Rij, 2010). The UK Government Office for Science finds it important that horizon scanning has a long time horizon, is cross-disciplinary (both policy and organization), and is challenging implicit assumptions about the future that underlie today's decisions (UK Government Office for Science, 2010). Lastly, the Australian Joint Agencies Scanning Network (AJASN) states that horizon scanning is aimed at investigating the strategic and operational environment and assessing the possible impact and outcomes of changes in those environments (Delaney and Osborne, 2013, p.56).

The OECD-definition emphasizes the timely detection of mainly technological changes. The definition of Van Rij states that it mostly involves developments on the periphery of our field of vision and that the results of the horizon scan are meant to make policy robust. The definition of the UK Government Office for Science focuses on the long term, arguing that horizon scanning needs to transcend individual domains, and the AJASN-definition focuses on the place of the changes and its possible impacts. In this paper, we mostly relate to the second, third and fourth definitions, because we do not want to look at technology alone, but we are looking for the new and unexpected in other societal domains as well, and because we want to establish a link between the results of the horizon scanning and policy. Incidentally, one may argue whether horizon scanning is a specific foresight *method* or a specific *approach* to the future, but for the purpose of this paper, the outcome of that discussion is not particularly relevant.

Since carrying out a foresight study, such as Horizon Scan 2050, is not a goal by itself, but is designed to inspire, initiate, inspire, support or make a future-related decision, we were curious about how the outcomes of the Horizon Scan 2050 affect the innovation policy of the Dutch government. Indeed, the OECD has advised the Dutch Ministry of Economic Affairs "to ensure the necessary dynamism in the top-industries in the light of societal challenges (…)" (OECD, 2014, p.5) and also the role of grand challenges in foresight is increasing (Boden et al., 2012).

The origins of the current innovation policy dates back, more or less, to 2007, when a so-called Innovation Platform was established with the aim of bringing more focus to this policy and thinking about the kind of industries on which the Dutch economy should focus and which should, subsequently, be supported by the Dutch government. This led to the formulation of the so-called Top-Industries, i.e. industries that should serve as the most important, most value-adding industries of the Dutch economy. The Top-Industries are listed in Appendix A.

However, if those industries should indeed be the most promising ones, would it not then be interesting to see whether these industries are indeed the most promising ones? Are they indeed future-proof? Are they indeed the industries with which the Dutch will earn their money in the future? These seem like logical questions, given the fact that innovation is closely related to the future, while earlier research has shown that the choice of these industries is partly influenced by lobby activities and that they tend to reflect the current strength of a particular industry, rather than its future potential (Van der Duin and Sabelis, 2007; Nauta, 2008).

This study aims particularly to provide insight into the role that the 'Grand Challenges' and 'Signals for Change' play in relation to the Dutch Top-Industries and to determine the robustness of these industries. This leads to the overall research question: "To what extent will the current Top-Industries prove to be future-proof in the light of the Grand Challenges and Signals for Change?" To answer this question as best as possible, we formulate two sub-questions.

1. To what extent do the Top-Industries contribute to the 'Grand Challenges'?
2. What kind of influence do the 'Signals for Change' have on the Dutch Top-Industries?

Horizon Scan 2050

In 2012, the STT decided to set up a broad foresight study aimed at identifying problems and opportunities for the long term (Scheerder et al., 2014). Although the existing portfolio consisted of long-term studies, they were of a predominantly thematic nature (such as gaming, wisdom of the crowds, IT, labor). There was no overarching study that included as many social domains as possible. The awareness of the growing intertwining of social domains and the need for a study that would also help determine new future themes led to the foundation of the *Horizon Scan 2050*. More specifically, the goals of the *Horizon Scan 2050* were:

- Providing **inspiration** for the development of research, setting up policy studies and the promotion of societal debates.
- Contributing to building a **vision**. For instance, the reflection on our society in 2050 allows us to create an image of possible future

profitable business models. What will the developments identified mean for our economy? Where will our future profits come from?

- Developing of **social or responsible innovation**. That is to say, input from experts suggests that, in the future, social and ethical factors may be more important than mere technological developments. Reflection on the various directions and shapes the future, as sketched in the *Horizon Scan 2050*, may take allows us to start a broad societal debate about the changes that are or are not desirable and inevitable.

A broad and long perspective on possible futures can make it tempting to apply all kinds of science fiction-related techniques, but in the *Horizon Scan 2050* mostly formal (or explicit) techniques were used to examine different futures. That is, the approach adopted in *Horizon Scan 2050* was a *systematic*[1] mix of analysis, creativity, and synthesis, whereby people took part in workshops both as individuals and in groups, and where both reports were included about the results of the desk research and external authors gave their personal vision on the collected material. The main goal of this approach was to make the project "a creative process of collective sense-making by a way of collecting and synthesizing observations (…)" (Könnölä et al., 2012, p.223). A visual representation of the method is provided in Appendix B, but we provide a brief description here:

1. The first stage of the Horizon Scan 2050-project consisted of a meta-analysis of existing studies involving the distant future, to identify Grand Challenges (GCs) and Signals for Change (SfCs), using key words like 'breakthroughs', 'signals', 'seeds (for/of change)', 'significant developments', etc.. A decision was made to focus on the GCs, since they have become such a key term in policy-making[2], modern foresight, and because they deal indeed with the future (Burgelman et al., 2014, p.6-7).[3] GCs have become a very important ″framework for addressing the critical themes in achieving a more sustainable EU and planet″ (Rhisiart, 2013, p.31). Despite their increasing popularity, definitions of grand (or global) challenges are scarce. Cuhls et al. (2012) state, based on their personal observation, that GCs, are being related to three perspectives: 1) a selection of megatrends in a global context; 2) identified global problems; 3) `unknown unknowns', or problems that have not yet been identified. Although `unknown unknowns' were part of the Horizon Scan 2050-project we did not use them in the study. We captured 'megatrends` in out Signals for Change (SfCs) and considered GCs mainly as problems (or issue) on a grand or even global scale. Therefore, in this study we follow the definition of the European Commission since they both address the scale of the

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[1] Miles and Saritas (2012, p.530) refer to a definition of horizon scanning by the Government Office for Science (2011) in which it is considered a "systematic examination of potential threats, opportunities and likely future developments…". Next, *systematic* implies to them a *structured process*.

[2] The Lund-declaration (2009) states that European research (and innovation) must move away and beyond current rigid thematic approaches by using grand challenges making it issue-oriented.

[3] Grand challenges are indeed on a global level, which means "grand in scope and level, and are generally made up of ′wicked problems` (….)" (Cagnin et al., 2012, p.140).

problems and emphasize its function in research and policy-making: *Grand Challenges are challenges 'of sufficient scale and scope to capture the public and political imagination, create widespread interest among scientific and business communities and NGOs and inspire younger people. They must be capable of acting as an important tool for percolating attention at all levels of society all the way down to the civil society and the public at large' (*European Commission, 2012). The Grand Challenges used in this study were: scarcity, climate change, demographic change, longer life, global power shifts, and new connectivity. The GCs are described more in detail in Appendix C.

2. The desk research was also used to identify a first inventory of the Signals for Change. After all, the SfC — expected or unexpected, rapid or slow, interacting or individually — determines the future of the GCs. It was decided to use the term 'Signals for Change' since not every possible future change is a trend or development (i.e., a change over time), but it can sometimes also be events, wild cards, weak signal or tipping points (see: Mendonça et al., 2004; Van der Duin et al., 2001; Ansoff, 1975; Ilmola and Kuusi, 1975, for definitions of these types of abrupt changes) that can have a major impact on future developments. The SfC were defined as follows: *A high-impact event leading to a disruption of or a change in a trend, influencing the Grand Challenges (GCs).* In addition: *A Signal for Change may be expected or unexpected, e.g. the emergence of new technologies in sustainable* energy' (Popper and Teichler, 2011).

The SfCs were categorized based on the STEEP-model: Society, Technology, Environment, Economy, and Politics. The desk research resulted initially in 150 SfCs, a number that was subsequently narrowed down to 57 by clustering. The 57 SfC are listed in Appendix D.

3. After gathering the 'raw material' in step 1 and 2, it was subjected to an analysis by setting up a survey in which the respondents were asked about the probability, possibility, and desirability of each SfC to add a certain 'value' to each SfC.

4. The next, six workshops were organized, each around a different GC and for which specific SfCs were selected. The outcomes of these workshops were rather diverse, the participants were free to write down or draw every association they had when combining the various SfCs with the particular GC.

5. A specific workshop was organized about the so-called 'unknown unknowns', since the project groups still wanted to make sure that no possible SfC were missing and to give participants another possibility to come up with things that one would never expect or want to believe.

6. All the material from the workshops was handed over to a few story writers, who were given all the freedom to be inspired by the material and asked to express their own personal future visions. After that, and in addition to it, the project group wrote a 'synthesis' that more or less reflected their views on the entire process, its outcomes, and its possible future consequences.

Research Structure

To answer the two sub-questions of the "Introduction" section, we use the following research framework:
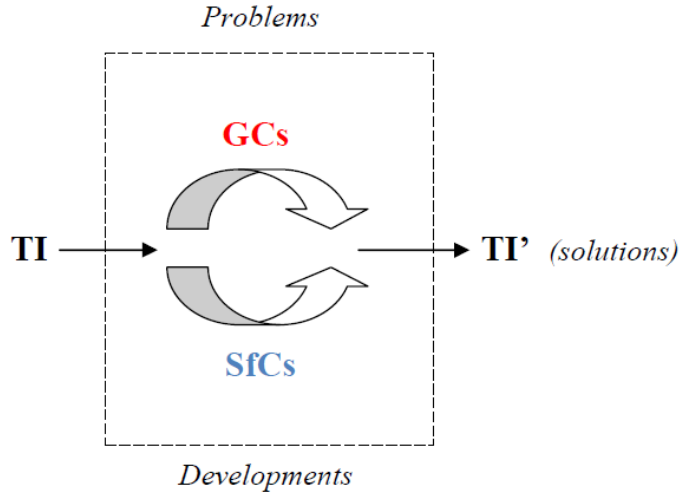
Figure 1. *Research Framework*

Figure 1 illustrates that the Top-Industries (TI) are tested to determine how future-proof they are against the Grand Challenges (GCs) and the Signals for Changes (SfC). We view the GCs as a kind of problems to which the TI should provide an answer. In addition, the SfC represent (future) developments that the TI should address. Note that ideally, on the basis of these two tests, a new TI (TI') should be developed, to provide new solutions to new problems and to address new developments. However, this part of the research framework was not included in our research.

To answer both research questions, opinions of 25 experts (60 experts were initially invited), ranging from full professors to product managers consultants, were collected on the level of influences between SfCs and GCs. We used the six GCs from the Horizon Scan 2050 and selected five SfC with the highest scores both on the impact and on probability, balanced across the various parts of STEEP. The expertise on foresight (i.e. the extent to which they are involved in foresight studies and projects) was indicated by the respondents themselves and presented in Figure 2. The level of expertise was considered sufficient for this study.

Figure 2. *Level of Foresight Expertise of the Survey Respondents*
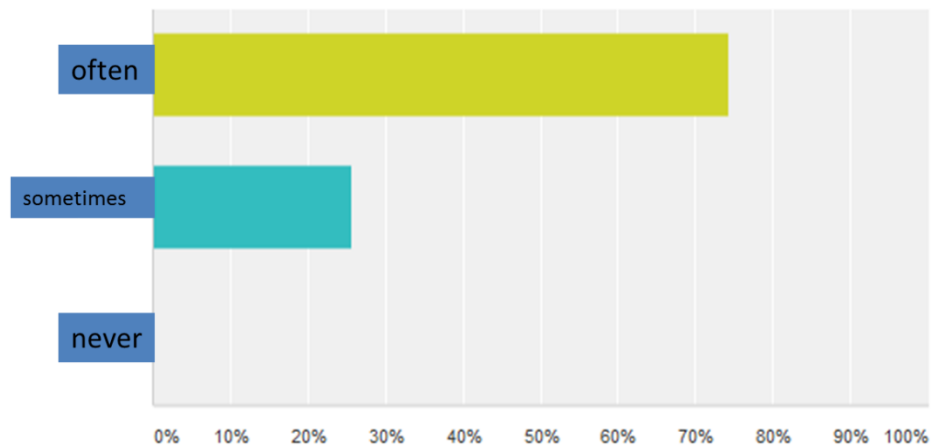
Results

The first result of our survey shows the combined scores or answers to the question regarding the estimated contribution of a given Top-Industry to a Grand Challenge. This, more or less, measures the societal relevance of a Top-Industry. Figure 3 shows that Life Sciences & Health, High-Tech, Energy, and Water had the highest scores. The Creative Industry, Logistics, Agri & Food, and Energy had the lowest scores. On average (far right column), we see that High-tech and Life Sciences & Health had the highest average, and that Logistics, the Creative Industry and Horticulture had the lowest score. The overall standard deviation was 0.488 which is sufficiently low for consensus.

Figure 3. *The Contribution of Top-Industries to a Grand Challenge*

Grand Challenge / Top industry	Scarcity	Climate change	Demographic changes	Longer life	Global power shifts	New connectivity	Averege score (row)
Agri & Food	6.8	5.6	5.7	6.7	6.1	3.7	**5.7**
Chemicals	6.7	6.3	4.6	5.7	5.4	4.0	**5.5**
Creative industry	4.2	4.0	5.2	5.9	5.0	6.8	**5.2**
Energy	7.0	6.8	4.5	5.1	6.7	5.2	**5.9**
High Tech	6.6	6.5	5.9	7.0	6.2	7.8	**6.6**
Life Sciences & Health	5.0	4.8	7.5	8.3	5.5	5.6	**6.1**
Logistics	4.9	5.3	4.8	4.8	5.0	5.8	**5.1**
Horticulture	6.2	5.2	5.2	5.4	5.2	3.8	**5.2**
Water	7.2	6.0	5.0	5.5	6.1	3.9	**5.6**
Average score (column)	**6.7**	**5.6**	**5.4**	**6.0**	**5.7**	**5.2**	

The second result of our survey shows the answers, or combined scores of the answers, regarding the extent of the influence of a SfC on a Top-Industry.

Figure 4 shows that the Creative Industry, Energy, and High-Tech have the highest scores, while Water, Agri & Food, and the Creative Industry have the lowest scores. On average (bottom row), we see that the High-Tech, the Creative Industry, and Agri & Food had the lowest scores. The overall standard deviation was 0.529 which is sufficiently low for consensus.

Figure 4. *The influence of a SfC on a Top-Industry*

Top industry / Signal for Change	Agri & Food	Chemicals	Creative industry	Energy	High Tech	Life Sciences & Health	Logistics	Horticulture	Water
All use and access to information is being controlled	5.3	5.7	6.8	5.9	6.8	6.6	6.0	5.4	5.4
Growth of experience economy: intangible products	5.3	4.7	8.1	5.1	6.9	6.4	5.5	4.8	4.6
Rise of carbon-oxide emission rights and limits	7.2	7.7	4.7	8.5	7.6	5.6	7.4	7.0	6.4
Complete dependence on information and communication technology	7.1	7.1	7.9	7.5	7.8	7.5	7.6	6.8	6.6
Creativitity is the largest generator of wealth	6.0	6.5	8.2	6.7	7.8	7.1	5.9	5.9	5.4
Average score (column)	6.2	6.3	7.1	6.7	7.4	6.6	6.5	6.0	5.7

The third set of results shows the combined scores of the Top-Industries (TIs) regarding their relevance to GCs and the extent to which they address SfCs. Ideally, a TI should have a good score with regard to the GCs as well as the SfCs. We call this *robustness*[4], which means that they are effective in terms of addressing a GC, and that they are sensitive, which means that they respond

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[4] The term *robustness* is strongly related to the scenario-method in which it means that policies are robust if they are in line with all (or most of the) scenarios meaning that a robust policy scores better than other policies across the different scenarios (Botterhuis et al., 2010, p.463). A more broad notion of robustness is provided by Van Asselt (2000, p.5) who states that a robust policy triggers a favorable future, avoids undesirables futures, and is also sufficiently flexible to cope with changing circumstances.

In this paper we use robustness in line with the notion of Botterhuis et al. since we state that a Top-Industry (i.e., a policy) is robust if it addresses various GCs as well as various SfCs (i.e., scenarios) without (on top of) having to influence or avoid a particular future or a Top-Industry having to be flexible.

In this sense the choice to invest governmental resources in a robust Top-Industry can also be considered to be a 'no-regret'-policy which means that regardless which future might unfold, i.e., which GC and/or which SfC will become important in the future, this policy choice will turn out good and is therefore advisable.

adequately to future developments or changes. The more the TIs address both aspects, the more robust they are considered. This framework is shown in Figure 5.

Figure 5. *The Framework Illustrating the Level of Robustness of the Top-Industries*

GC score (row average)/ SfC score (column average)	High (suficient)	Low (insufficient)
High (sufficient)	Useful and sensitive for developments: robust	Not useful but sensitive for developments: if adjusted, perhaps robust
Low (insufficient)	Useful but not sensitive for developments: robust on the short term	Not useful and not sensitive for developments: not robust

We assess the robustness by combining the GC-scores (Figure 3, far right column) and the SfC-score (Figure 4, bottom row).

Figure 6. *The Robustness-Scores of the TIs*

| Top Industry (solutions)	Contribution to adressing/solving six Grand Challenges (problems)	Under influence of five Signals for Change (developments)
Agri & Food	5.7	6.2
Chemicals	5.5	6.3
Creative industry	5.2	7.1
Energy	5.9	6.7
High Tech	6.6	7.4
Life Sciences & Health	6.1	6.6
Logistics	5.1	6.5
Horticulture	5.2	6.0
Water	5.6	5.7
Standard deviation	0.488	0.529

Figure 6 shows that High-Tech has a high score on both elements and is therefore considered the most robust of all the TIs. The other TIs score relatively well on one aspect, but not on both aspects. Logistics, Horticulture, and Water have an overall low score. Figure 7 shows the Tis with a score higher than 6 of Figure 6 in the matrix of Figure 5. Water is indeed a TI with a low robustness:

Figure 7. *Scores of the TIs above 6*

GC score / SfC score	High (sufficient >6)	Low (insufficient < 6)
High (sufficient > 6)	Useful and sensitive for developments: robust **High-tech** **Life sciences & health**	Not useful but sensitive for developments: if adjusted, perhaps robust **Chemicals** **Creative industry** **Logistics** **Agri & Food** **Energy**
Low (insufficient <6)	Useful but not sensitive for developments: robust on the short term **Horticulture**	Not useful and not sensitive for developments: not robust **Water**

Since the robustness scores were compiled afterwards by combining answers to separate questions, we added a control question to the survey, asking the respondents directly which top-industries they considered to be robust or future-proof. Figure 8 shows the outcome:

Figure 8. *Future-Proofness or Robustness of the Top-Industries*
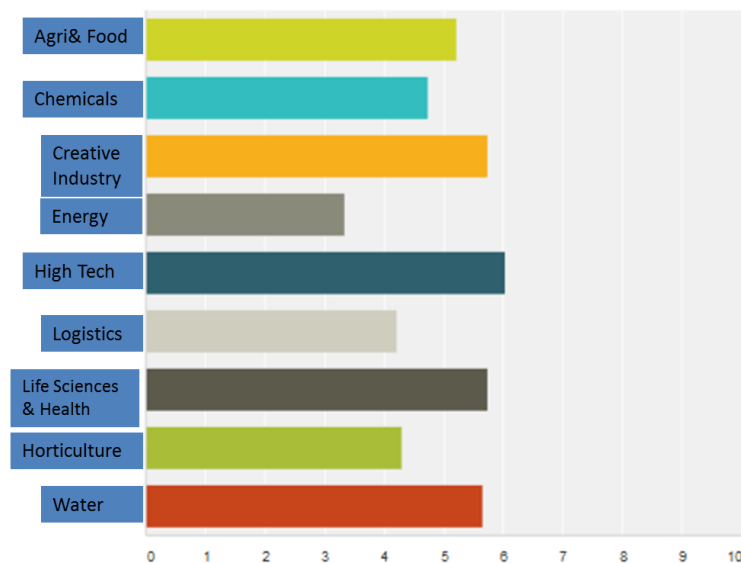
Although Figure 8 shows no clear significant outcomes, it does confirm the future-proofness of High-Tech and Life Sciences & Health. In addition, respondents are convinced of the future-proofness of the Creative Industry

Conclusions and Recommendations

Based on the results presented above, we can draw the following conclusions:

1. Overall, the scores are relatively low, and there are not many real significant differences between the scores. This may be explained by the fact that the survey was fairly comprehensive, and therefore fairly complex.

2. Despite the moderate scores, we can conclude that High-tech and Life Sciences & Health are the *winners*. They have the best overall scores and can be considered the most robust or future-proof Top-Industries.

3. The Creative industry is a relatively new industry and is quite different from the other top-industries, due to its relatively high level of heterogeneousness. However, the industry as such is growing in the Netherlands, in terms of turnover and employment, and its scores in this survey are not bad at all, especially regarding the SfC.

4. Water scores low if one combines the separate scores of the survey, but scores high on the future proofness-question. It is difficult to explain this difference, given the fact that Water has always been a top-industry in the Netherlands, even before this concept was used as a pillar for the Dutch innovation policy. Without up-to-date knowledge about water management, the Netherlands would not even exist as a country. However, its low scores in the survey are to some extent compensated by the answers regarding the general future-proofness question. Apparently, although the Water industry may not relate very well to the GCs and the SfCs, it has indeed some appeal to the respondents, if we take the future as a more general concept, which we did in the particular question.

5. We noticed a surprising low score of for Top-Industry Energy in the survey. Surprising because so many developments are currently going on in that industry (e.g., privatization, liberalization, rapid developments in all kinds of renewable energy sources, political tensions) that we would have expected higher scores. This might be explained by the fact that energy is often taken for granted by people in general and apparently by the foresight experts as well. As a result, the energy industry may be considered less of a commercial industry and more of a utility industry that is or should not be influenced by any type of future change, whether it be a GC or a SfC. Another explanation might be that the abundance of gas in the Dutch soil has, as has often been suggested, weakened the Dutch economy because of its secure revenues (to a significant extent from exporting gas). The well-known 'Dutch disease' has been linked to this and, as result, the energy sector, although vital to both economy and society, is not considered as a (Top-) industry in which a country should invest more than the necessary.

Based on the results and the conclusions, we formulate the following recommendations:

1. For the survey we could use all the six GCs, but we had to make a selection of the SfC since there were simply too many (i.e., 57) to make a survey that would not ask too much time from the respondents. Therefore, the scores of the TIs on the GCs should be taken more seriously than those on the SfCs. In other words, the level of robustness of the top-industries could change on the basis of expanding the set of SfCs. Perhaps a next survey could be carried out with the same GCs and different SfCs, so that we could compare the outcomes of the different surveys and increase the validity of the survey.

2. In this survey, the Top-Industries were considered independent from each other. However, in practice these industries often work together (as well as with top-industries that have not been defined by the Dutch government as top-industries), thereby developing so-called 'cross-overs'. Consequently, it would be advisable for the Dutch government to stop thinking in terms of separate industries, but to pay much more attention to the connections between different industries.

3. The main goal of this survey was to test the future-proofness of the Top Industries. However, the GCs and the SfCs can also be used as a source of inspiration when thinking about new businesses and new industries. At present, it would appear that the Top-Industries that were defined as such reflect areas in which the Dutch excel, and this is projected onto the future. Needless to say, history is full of examples why one should not always extrapolate the present into the future. In particular since the outcomes of this survey show that some of the current top-industries are considered to be no future proof, some thinking and brainstorming about new, future top-industries may be required.

4. In addition to the two points listed above, the Top-Industries have also been defined too broadly. Energy, Water, High-Tech, and Chemicals, for instance, cover many large parts of the Dutch economy and there may even be some overlap. Also, for a future survey, it would be better to use more narrowly defined industries to allow respondents to better judge their robustness.

5. Obviously, the validity (both internal and external) could benefit from extending the empirical base of the survey involving more respondents. In addition, the survey may be more (Top) industry-based, so that we could invite more industry-experts rather than (or next to) foresight experts, because they have a deeper knowledge of the industry involved.

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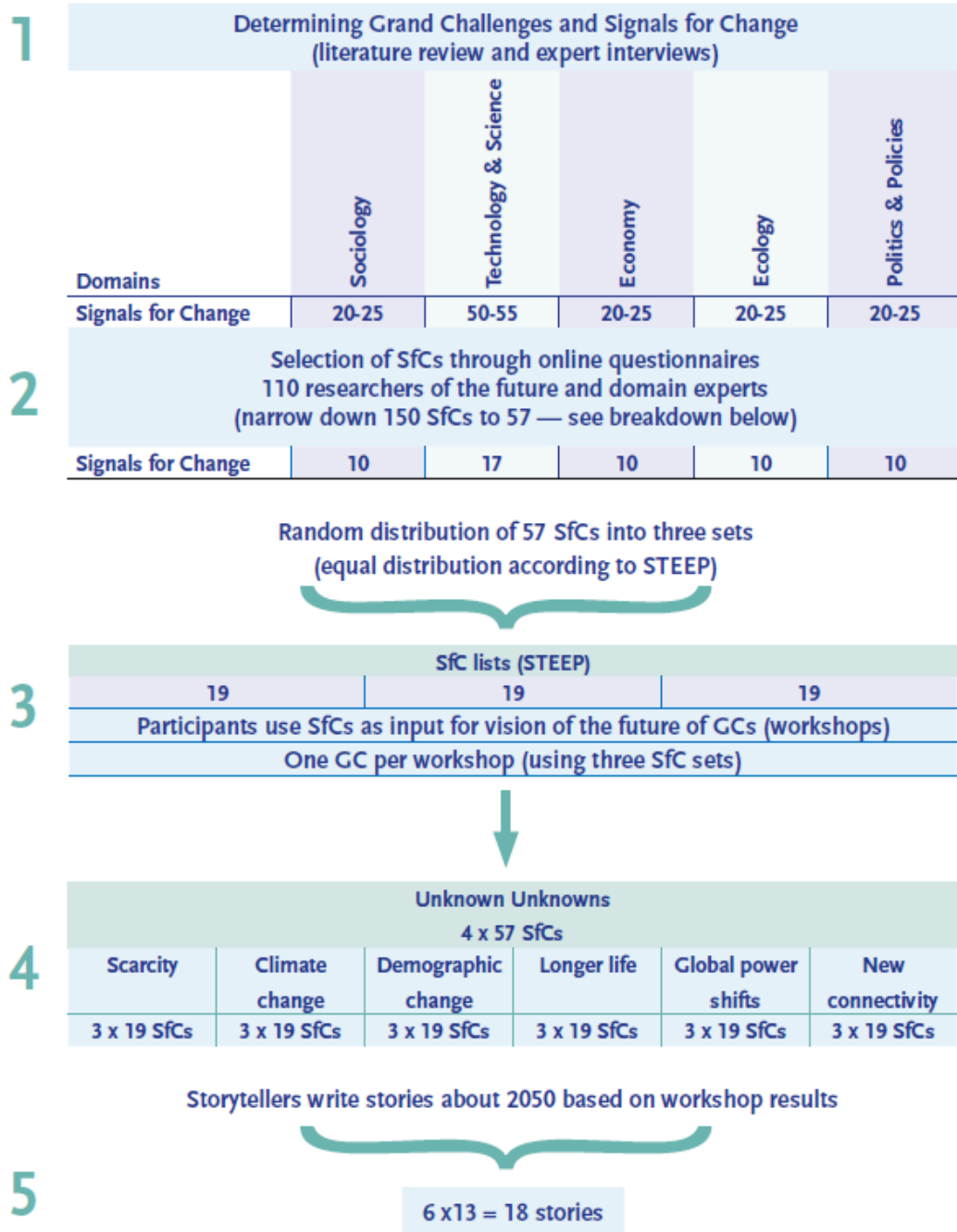
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Appendix A. The Top-Industries

- Agro & Food: value added in 2013: 43,857 million Euros.
- Chemicals: value added in 2013: 11,646 million Euros.
- Creative Industry: value added in 2013: 10,535 million Euros.
- Energy: value added in 2013: 29, 722 million Euros.
- High Tech Systems and materials: value added in 2013: 46,163 million Euros.
- Life Sciences & Health: value added in 2013: 4,672 million Euros.
- Logistics: value added in 2013: 53,021 million Euros.
- Horticulture: value added in 2013: 8,355 million Euros.
- Water: value added in 2013: 5,138 million Euros.

Appendix B. Procedure Horizon Scan 2050

Procedure STT Horizon Scan 2050

1 — Determining Grand Challenges and Signals for Change
(literature review and expert interviews)

Domains	Sociology	Technology & Science	Economy	Ecology	Politics & Policies
Signals for Change	20-25	50-55	20-25	20-25	20-25

2 — Selection of SfCs through online questionnaires
110 researchers of the future and domain experts
(narrow down 150 SfCs to 57 — see breakdown below)

Signals for Change	10	17	10	10	10

Random distribution of 57 SfCs into three sets
(equal distribution according to STEEP)

3

SfC lists (STEEP)		
19	19	19

Participants use SfCs as input for vision of the future of GCs (workshops)
One GC per workshop (using three SfC sets)

4

Unknown Unknowns 4 x 57 SfCs					
Scarcity	Climate change	Demographic change	Longer life	Global power shifts	New connectivity
3 x 19 SfCs	3 x 19 SfCs	3 x 19 SfCs	3 x 19 SfCs	3 x 19 SfCs	3 x 19 SfCs

Storytellers write stories about 2050 based on workshop results

5

6 x13 = 18 stories

Appendix C. Grand Challenges

1. Scarcity: Economic growth means the use of scarce natural resources. If people become richer they will use up more energy, water and food, and create more waste. Technological advances often also lead to increased consumption, as well as to new challenges (rebound effect). The much acclaimed introduction of biodiesel, for instance, led to an undesired decrease in farmland used for food production.

2. Climate Change: It is believed that climate change (through the greenhouse effect and global warming) will render specific regions on earth uninhabitable]. Weather conditions may become more unstable and more extreme. This will, for instance, increase the risk of large hurricanes and disastrous floods. Extreme heat and lack of water may turn specific parts of the world into deserts. Cities lying on the coast may disappear into the ocean. Is the changing climate caused by mankind or is it simply the result of a *natural* climate change? Human actions seem to have an influence on climate change, but more importantly: climate change has large implications for human life. The challenge is to maintain its sustainability on the behalf of future generations.

3. Demographic change: During the next decades improved healthcare, more access to education and higher living standards will lead to a population increase. According to the UN and OESO the world population will increase to 9 billion people in 2050, with a peak of 9.2 billion in 2075, an additional two billion people in forty years. In other words, there will be increased competition over scarce resources (see GC Scarcity). The average life expectancy for each region differs, but on a global scale it will rise. As of 2030 a life expectancy of 106 will no longer be surprising. The notion of 'old age' will have to be redefined. In many developed economies 55 years old is middle-aged now. If the global trend of people migrating to cities continues, more people will be living in cities than ever before (urbanisation).

4. Longer life: The average life expectancy in the West has risen extremely fast. In combination with a falling birth rate this leads to the ageing of the population, and — consequently — turns the care of the elderly into a challenge, especially when it comes to the informal (family) care of women. The growing demand for healthcare is also felt on the labour market. Almost 75% of the primary caregivers are female, and more than 30% of the people caring for a family member also have a job. Work and informal care giving are in each other's way. They are indications that increasing prosperity leads to changing values and ambitions, also in emerging economies. A higher life expectancy and more prosperity make people look differently at the quality of life. The living standard in the various regions is still measured in Gross Domestic Product (GDP) per capita. But this may change. Think, for instance, of the so-called Happiness Index. In more prosperous societies materialism and consumerism are gradually losing their attraction. In the future people will probably mainly want to measure the quality of life.

5. Global power shifts: State borders and geopolitical relationships resulted from centuries of voyages of discovery, from colonisation,

decolonisation, wars and the Cold War. Much of the political unrest in the world is caused by the globalisation of the economy. In addition, a global power shift is taking place. Asia is becoming more powerful. During the past ten years Asian countries have accounted for half of the global growth of the Gross National Product (GNP). All indications are that within the next ten years Asia will dominate Europe and the US. The fast rise of India and China will lead to a multi-polar world in which the US is no longer supreme.

6. New connectivity: An increasing number of obligations and networks exist outside the family context. This leads to less cohesion in families and households, influenced by technological developments in mobile communication, social media and computers. Our social tissue appears to change from 'blood relationships' to 'chosen relationships'. Relationships are increasingly driven by (temporary) affiliations and interests. The next generation, also called digital natives, will change the rules of the game. This generation will be a dominating power in the ageing West, even if the economic growth is zero. Shortages on the labour market will force employers to be flexible or move away. The younger generation will demand more flexible and attractive labour conditions in line with their own ambitions. This generation will also be 'hyperconnected'.

Appendix D. Signals for Change

SOCIETAL SIGNALS

1 Reduced solidarity
2 Reduction of the welfare state in many (European) countries
3 Enriched reality
4 Decreasing difference between the virtual and real world
5 All use of information is controlled. A different approach to privacy
6 Rise of robots in daily life: robots will be better in daily tasks than humans
7 The advent of singularity: the moment that man and machine become one
8 Growth in economic importance of the creative sector
9 Extreme self-organisation and self-sufficiency
10 A behavioural change towards a more holistic approach in life

TECHNOLOGICAL SIGNALS

11 New alternatives for oil in the manufacture of plastic, such as biomass and methane

12 Use of algae for the production of e.g. food, chemicals and fuel

13 Emergence of a fourth-generation nuclear reactor (Travelling Wave Reactor) turning fertile material into fuel

14 Artificial photosynthesis: using sunlight to convert CO_2 (and water) into oxygen and carbohydrates (sugars)

15 Breakthrough in cold fusion

16 Possibilities of a new generation in IT

17 Growing potential of stem cells

18 Use of chips in the human body to monitor health or as identification

19 Hybrid-assisted limbs: an external skeleton enabling (previously) impossible movements

20 The exocortex: an artificial brain that is far more advanced than the human brain

21 Skin embedded touch-screens: means of communication and body monitor in one

22 Embodied avatars: remote-controlled physical avatars interacting with their environment

23 Prediction of human behaviour through big data analysis

24 Arcology: combining architecture and ecology

25 Drones: autonomously flying 'vehicles' on every driveway

26 Rise of programmable matter adapting autonomously or through user input

27 Utility fog: a 'nanomist' of tiny robots able to replicate a physical structure that continually adapts on its own

ENVIRONMENTAL SIGNALS

28 Widespread melting of Arctic and Antarctic Poles

29 Recovery of biodiversity e.g. to counter exhaustion of natural resources, with less or no damage to the environment

30 Desalination of water to meet increased demand for drinking water

31 CO_2 storage and trade in CO_2 emissions

32 Lab-grown artificial food such as artificial meat to (partly) replace consumption of natural meat

33 Extreme rise of sea levels

34 Collision of an asteroid, comet, or other celestial object with earth

35 Colonisation of Mars

36 Global mentality change to counter the effects of climate change

37 Global growth of prosperity with a focus on the environmental footprint

ECONOMIC SIGNALS

38 Risk of cyberterrorism endangering the stability of the economic system
39 Increased global inequality between poor and rich
40 The experience economy: goods become services
41 Decreased importance of cities
42 World economy disrupted by wars
43 The end of Moore's Law: the process of ever faster increasing computer capacity slows down
44 The limits of economic growth
45 Breakdown of the global economy and rise of barter
46 Dollar loses status of world reserve value
47 Changing global economy through digitisation and robotisation

POLITICAL SIGNALS

48 Changing global politics
49 Loss of trust in national politics and government: need for a new system
50 Energy crisis caused by geopolitical developments
51 Europe becomes a federation of national states
52 Changing political alliances
53 Increased risk of (world) war
54 Risk of regional wars
55 Threat of bioterrorism
56 Use of nuclear weapons: risk of human extinction
57 Nuclear disarmament