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Scenario generation:

Enhancing scenario generation and quantification

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Abstract

This technical paper addresses improvements to the scenario generation stage of the Centre for Workforce Intelligence's (CfWI) robust workforce planning (RWP) framework, in particular on scenario generation and quantification. The methods have been tested on a new project – Horizon 2035 – the purpose of which is to consider different workforce futures for health, social care and public health 20 years from now.

The CfWI uses scenarios to explore a range of plausible but challenging futures. Each scenario represents a possible future that workforce planning may need to address. Some workforce policies may perform well across all these futures; we would then say that they are *robust* against future uncertainty. However, other policies may not perform as a well. Specific scenarios may be challenging and the outcome may not be good. Judgement is needed as to which policy to choose in situations where several policies perform adequately, but no single policy is outstanding.

This paper includes the following:

- a short review of the history of scenarios and scenario planning, the different types of scenario and methods for generating them
- a formal approach for creating a set of scenarios to present alternative, plausible and challenging visions of the future to inform workforce planning
- a method for checking the consistency of scenarios, so that only consistent ones are taken forward for quantification and modelling.
- a best-practice method for eliciting uncertain scenario parameters (all scenarios contain parameters that are inherently unknowable but where values need to be defined for modelling and simulation; this requires input from experts using a formal and defined protocol)
- an approach for generating scenarios at different levels of scale, where higher-level scenarios frame scenarios at a lower level of detail, enhancing the coherence of the overall set
- substantive improvements to the scenario generation process as a result of the above, and areas for future research.

This document also demonstrates where the research has improved the CfWI method for strategic workforce planning, through the impact it has had on the Horizon 2035 project (HS2035).

JEL Classification	000, 000, 000, 000, 000
Keywords	Centre for Workforce Intelligence, healthcare, social care, health policy, horizon scanning, scenario generation, systems thinking, system dynamics, workforce planning

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Key points

1. The CfWI has investigated how the scenario generation process can be improved.
2. Several new approaches have been successfully trialled and tested on the Horizon 2035 project, and the findings are reported.
3. The scenario process has been formalised, documented, and a larger number of scenarios can now be produced. The restriction to a maximum of four scenarios has been removed.
4. Scenarios can be tested for consistency, and this approach also allows additional scenarios to be generated for situations where uncertainty is high, and it is important that the scenarios span the full range of this uncertainty.
5. Several approaches are being trialled for improving the quantification of scenarios, and it is hoped these will replace the current online Delphi method, which has proved problematic.
6. The concept of scenarios at different levels of scale (multi-scale scenarios) has been tested, and there is considerable potential in using this approach to remove inconsistencies and generate system-wide insights.

Areas for future research have been identified, and will be reported in future technical papers.

Contents

1. Introduction

This technical paper addresses improvements to the scenario generation stage of the Centre for Workforce Intelligence's (CfWI) robust workforce planning (RWP) framework, in particular on scenario generation and quantification. The impact of these improvements is demonstrated with reference to the enhanced scenario generation approaches used in the Horizon 2035 (HS2035) project (CfWI, 2014a).

The CfWI uses scenarios to explore a range of plausible but challenging futures. Each scenario represents a possible future that workforce planning may need to address. Some workforce policies may perform well across all these futures; we would then say that they are *robust* against future uncertainty. However, other policies may not perform as a well: specific scenarios may be challenging and the outcome may not be good. Judgement is needed as to which policy to choose in situations where several policies perform adequately, but no single policy is outstanding.

This section describes how scenarios and scenario planning have been used to inform decision making, and how scenario planning is used by the CfWI in the RWP framework.

1.1 Background to scenarios and scenario planning

A scenario is a description of a possible and plausible future situation, and the path or paths leading to that future. Scenario thinking or scenario planning is the use of scenarios to support thinking about the future, including setting goals, formulating strategy and undertaking detailed development planning.

Scenarios have a long history. Scenario planning is often thought to have begun with Herman Kahn in the 1950s at RAND. He used scenarios as a method for analysing military strategies and 'thinking the unthinkable', as illustrated in his book *On thermonuclear war*, which was 'dedicated to the goal of anticipating, avoiding, and alleviating crises' (Kahn, 1960).

However, similar approaches were being developed in the late 1950s in other countries, for example in France by Gaston Berger who used the term *la prospective,* which according to Godet (2001) is best translated as strategic scenario building, and intimately links strategy, planning and practice. Berger founded the *Centre Universitaire International et des Centres de Prospective* and is regarded in France as the father of the discipline. These are just two examples in the long history of scenarios and scenario planning; no doubt there are many others not given adequate mention in the literature.

The use of scenarios soon moved from military planning to the realms of business and strategy. Companies such as the Stanford Research Institute (SRI) International, Global Business Networks (GBN) and Royal Dutch Shell pioneered and formalised the approach (van der Heijden, 1996). Pierre Wack, head of corporate planning for Royal Dutch Shell, is credited with refining the use of scenarios to guide strategy and in foreseeing the oil price shock of the 1970s. For a good history of the Shell scenario method, see the articles by Cornelius et al. (2005) and Wilkinson and Kupers (2013).

Scenarios may be qualitative in nature: carefully constructed stories that emphasise possible futures we may need to avoid or steer towards. They may be modelled to provide quantitative outputs that can be ranked and analysed. Scenario planning is now used by a significant proportion of organisations as a tool to aid decisions, cope with future uncertainties and build consensus for change. There is large body of literature about the method (Bishop et al., 2007), including applications such as strategic thinking and organisational learning (van der Heijden et al., 2002), potential improvements (Postma and Liebl, 2005) and the benefits for decision-making (Meissner and Torsten, 2013). The CfWI have used scenarios in a number of strategic workforce studies (CfWI, 2012a; 2013b; 2013c).

1.2 Uses of scenarios

There are many ways that scenarios can be used, as noted by Wright, Bradfield and Cairns (2013):

- **sense-making**: a one-off exploratory question-raising scenario project
- **developing strategy**: a one-off decision-making scenario project
- **anticipation**: an on-going exploratory scenario activity
- **action-based organizational learning**: an on-going decision-making activity.

This technical report concentrates on the applications of the scenario method to capturing the uncertainty of the future to support workforce planning. As noted previously, the CfWI uses scenarios to help planners and decision-makers think about the future. This is important given that actions taken today may not impact the workforce for many years. For example, it takes over 15 years to train a speciality hospital doctor, during which time the needs of the population and their behaviour may have changed, or technological developments may have reduced the need for costly medical interventions. However, there is much uncertainty. It is possible that technology may have created new opportunities that drive increased demand for new treatments. Furthermore, the length of the training supply pipeline means that there is a lag between actions that change intakes, and the production of trained workforce. This can lead to situations of oversupply or undersupply, where decision-makers fail to take account of these delays.

1.3 Scenario planning and the CfWI's robust workforce planning (RWP) framework

Scenarios are a key part of the CfWI's RWP framework (2013a). The RWP is a structured approach to strategic workforce planning. The framework is composed of the following stages:

1. **Horizon scanning** – Horizon scanning explores the potential challenges, opportunities and likely future developments that could influence workforce planning. These include technological, economic, environmental, political, social and ethical influences on an unfolding future.

2. **Scenario generation** – Ideas from the horizon scanning stage are captured, synthesised and used to inform the scenario generation stage, where plausible future scenarios are created, quantified and used to inform workforce planning.

3. **Workforce modelling** – The purpose of workforce modelling is to project demand and supply for a range of plausible futures, as described by the scenarios. Further modelling is then conducted to determine the robustness of policy options for achieving a sustainable balance of demand and supply.

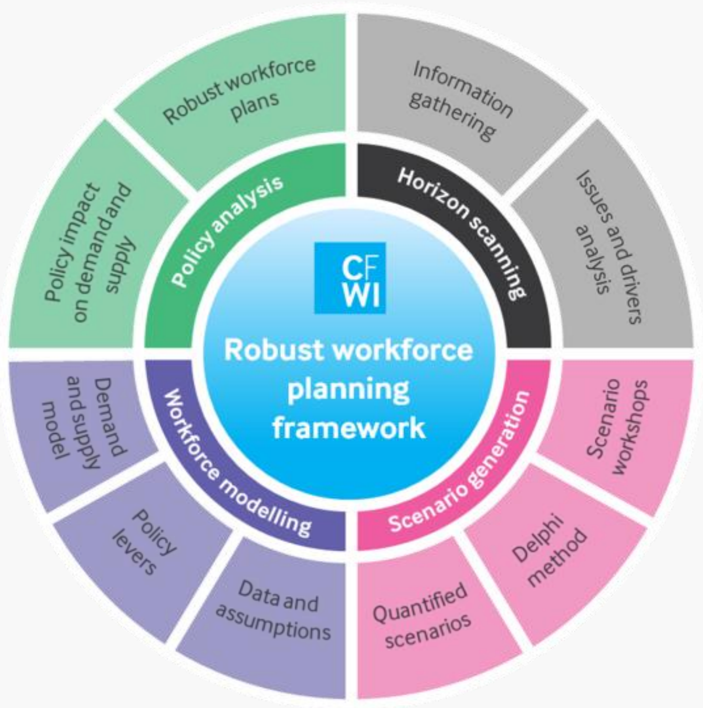
4. **Policy analysis** – Workforce intelligence focuses on analysing future uncertainties and the impact of policy options, and presenting the findings. By considering multiple future scenarios, different

options can be tested to see which one is the most robust. There will be that lead to favourable outcomes across all futures and others where the outcome is less clear.

The framework is described in more detail in *CfWI technical paper no.1*, and is illustrated in Figure 1 below.

Figure 1: The CfWI robust workforce planning framework (RWP)

The robust workforce planning (RWP) framework has been developed by the CfWI to carry out informed workforce analysis. The framework is composed of horizon scanning, scenario generation, workforce modelling and policy analysis. The framework is described in full in *CfWI technical report no.1* (CfWI, 2013a).



Source: The Centre for Workforce Intelligence

1.4 Structure of this document

This document provides more detail about the methods used by the CfWI in the creation of scenarios and the improvements that our research has made to the scenario planning process. This document is structured as follows.

- **Section 1** is an introduction and background to scenarios, scenario planning and the role of scenario planning in the CfWI's robust workforce planning framework.
- **Section 2** involves an overview of scenario methods, including classification and approaches to generating scenarios.

- **Section 3** is creating scenarios for workforce planning. There is a description of a scenario generation approach used by the CfWI to develop plausible scenarios, with examples provided from the HS2035 project.

- **Section 4** involves ensuring consistent scenarios. Whatever the approach used to create the scenarios, the scenarios themselves need to be consistent. A consistent scenario is one where the factors defined in the scenario have future outcomes that make sense. For example, if one factor is the state of the economy and the other is investment in research, a strong economy is consistent with a high level of research funding, and less consistent with a low level. Conversely, a weak economy is consistent with a low level of funding and less consistent with a high level.

- **Section 5** is eliciting uncertain scenario parameters. Where scenarios are going to be modelled, those parameters that are uncertain, that is vary across the range of futures defined by the scenarios, need to be quantified. Since they are inherently uncertain, their likely range (i.e. their distribution) needs to be elicited[1].

- **Section 6** is creating multi-scale scenarios. Scenarios may be produced at different levels of scale, for example combined health and social care, health-specific, social care-specific and individual workforce-specific scenarios – which are internally consistent at the level at which they are produced. The higher-level scenarios will frame the scope for the lower-level ones, increasing overall coherence of the set.

- **Section 7** contains next steps, including future directions for research.

[1] The subjective judgement of experts is typically represented as a probability density function (PDF), which is their assessment of the relative likelihood of a parameter taking a given value.

2. Scenario methods

There are many ways of defining, developing and using scenarios; some unstructured and others highly formalised. This variation is in part due to the lack of a consistent definition of the term amongst scenario planners and the multiple applications of scenario planning. As Mietzner and Reger (2004, p. 50) note: 'The term scenario describes a fuzzy concept that is used and misused, with various shades of meaning'.

Scenario planning exercises can be used to create stories about plausible alternative futures, supported by graphics and research to build a compelling picture to help decision-makers. Typically only a small number of scenarios are created, a trade-off between the effort required to create them and the maximum number it is felt can be presented and understood. Three or four scenarios are not uncommon. Other approaches may vary the parameters of interest to create hundreds or even thousands of scenarios in the hope of covering all possible futures. The challenge then is how to present these outputs in a form that can be readily understood and acted on.

2.1 Types of scenario

Scenarios can be grouped into three broad areas: predictive, exploratory and normative (Börjeson et al., 2006):

- **Predictive scenarios** are concerned with **what is going to happen** in the future.
- **Exploratory scenarios** are concerned with **what might happen** in the future.
- **Normative scenarios** are concerned with **how a desired future might be reached**.

This categorisation covers the probable, possible and preferable futures.

There are many other typologies: for example, that of van Notten et al. (2003) explores three overarching themes (project goal, process design and content) to identify 14 scenario characteristics.

Exploratory scenarios have their roots in the work of Kahn and colleagues and the intuitive logics model as practised at Royal Dutch Shell, often referred to as the 'gold standard of corporate scenario generation' (Millet, 2003). This approach, although appealingly simple since it relies on intuition, demands a great deal of research, preparation and skill. As Kees van der Heijden states:

> 'Scenario planning is a practitioner's art. Its origins are in the real world of management, it is therefore more a craft than a science. Over the years a number of general principles have emerged but most of the rules of implementation evolve from day-to-day practice. It has in common with any other craft that there is not just one way of practising it.'
>
> van der Heijden (1996, p.133)

The focus is on making decisions around a key issue of concern. Defining this question is critical to the method and is the thread that runs through it. The intuitive approach as pioneered by Peter Schwartz (1996) and described by Wright and Cairns (2011) is broadly as follows.

1. Set the agenda for the exercise including the focal question and the scenario timescale.
2. Determine the key factors or driving forces in the local environment.
3. Cluster the driving forces into higher level groups.
4. Define two extreme but plausible outcomes or resolutions for the clusters.
5. Rank the clusters by impact on the focal question and uncertainty of outcome, and determine the key scenario axes A and B.
6. Frame the scenario around the extreme outcomes of the key factors, A1, A2 and B1, B2.
7. Scope and build the scenario descriptions.
8. Develop the scenario storylines including the key events and chronology.

To make the scenarios memorable they are often given highly descriptive titles such as 'You are on your own'[2] and supported by graphics and other visualisation methods. The approach critically depends on having the right people to run to exercise and build the scenarios. The Shell new lens scenarios are good example of this method (Shell, 2014) and although the scenarios and the approach look deceptively simple they are the product of considerable data gathering, research and analysis, and highly skilled practitioners.

Normative scenarios are built around desired futures and often work backwards (backcasting) to investigate how to reach a target. The storyline then becomes the sequence of events and actions leading to this future, which may include different converging pathways. A critical part of the exercise is goal setting: deciding what we want to achieve and thus what we want the future to look like. Analysis of the possible paths to this future may help in deciding the process by which the future may be reached, and identify points where actions need to be taken, or where the path may split. The normative approach is built on the assumption that the future can be influenced and shaped in the desired direction. In contrast, the explorative method recognises unpredictability. Normative scenarios have parallels with the *la prospective* school of scenario planning (Rounsevell and Metzger, 2010, p.608) in their focus on creating the future.

Predictive scenarios are concerned with an expected or baseline future. This may be derived from extrapolating trends, which are usually assumed to continue as at the present, either judgementally or using mathematical modelling if data are available. Accurate predictions depend on understanding how the structure and laws governing the system might change over the time period.

The following section provides a description of the scenario generation method as practised by the CfWI on the HS2035 project.

[2] This is one of three scenarios produced by the World Economic Forum on the future of pensions and healthcare in a rapidly ageing world (World Economic Forum, 2008). The other two scenarios are: 'We are in this together' and 'The winners and the rest'.

3. Creating scenarios

The CfWI has adopted a formalised approach for developing rich, consistent scenarios based on systems thinking principles and scenario generation best practices. The approach has been demonstrated to be highly effective across a number of workforce reviews where scenarios were required (CfWI, 2012a; 2013b; 2013c). This section describes the CfWI's approach, with particular reference to the HS2035 project.

Scenario creation demands the production of a set of futures that are provocative but consistent. They need to be easy to understand but not simplistic. These futures also need to be sufficiently detailed so as to paint a rich picture of a future that while very unlikely, could plausibly happen. Such scenarios would be qualitative and explorative. The scenarios have to be sufficiently diverse so as to present a range of challenging futures, but not so many that they are impossible for busy people to understand. This could mean from between three to five or six scenarios, but probably not many more. The crucial issue is choosing the best set of scenarios and deciding how they should be presented.

The CfWI has developed a formal but flexible approach for developing consistent scenarios with stakeholders from the area under investigation. The approach has been successfully used across a number of projects (CfWI, 2012a; 2013b; 2013c). It is based on a number of methods described in the literature, especially the exploratory approach (Wright and Cairns, 2011) and the concept of scenarios at different levels of scale (Millennium Ecosystem Assessment, 2005, pp. 61-83). These methods have been adapted to meet the particular need that the CfWI has for scenarios in robust workforce planning. For example, the narrative scenarios that are produced are designed so that their critical uncertainties can be quantified for modelling.

A particular emphasis has been placed on integrating systems thinking methods into the scenario generation process. Systems thinking methods provide a way of analysing and better understanding a system by taking into account the fundamental cause-and-effect relationships that drive system behaviour (Meadows, 2008).

This section describes the CfWI scenario generation approach. Each stage of the approach is defined, together with how it has been applied to the HS2035 project.

3.1 Overview of the CfWI scenario generation method

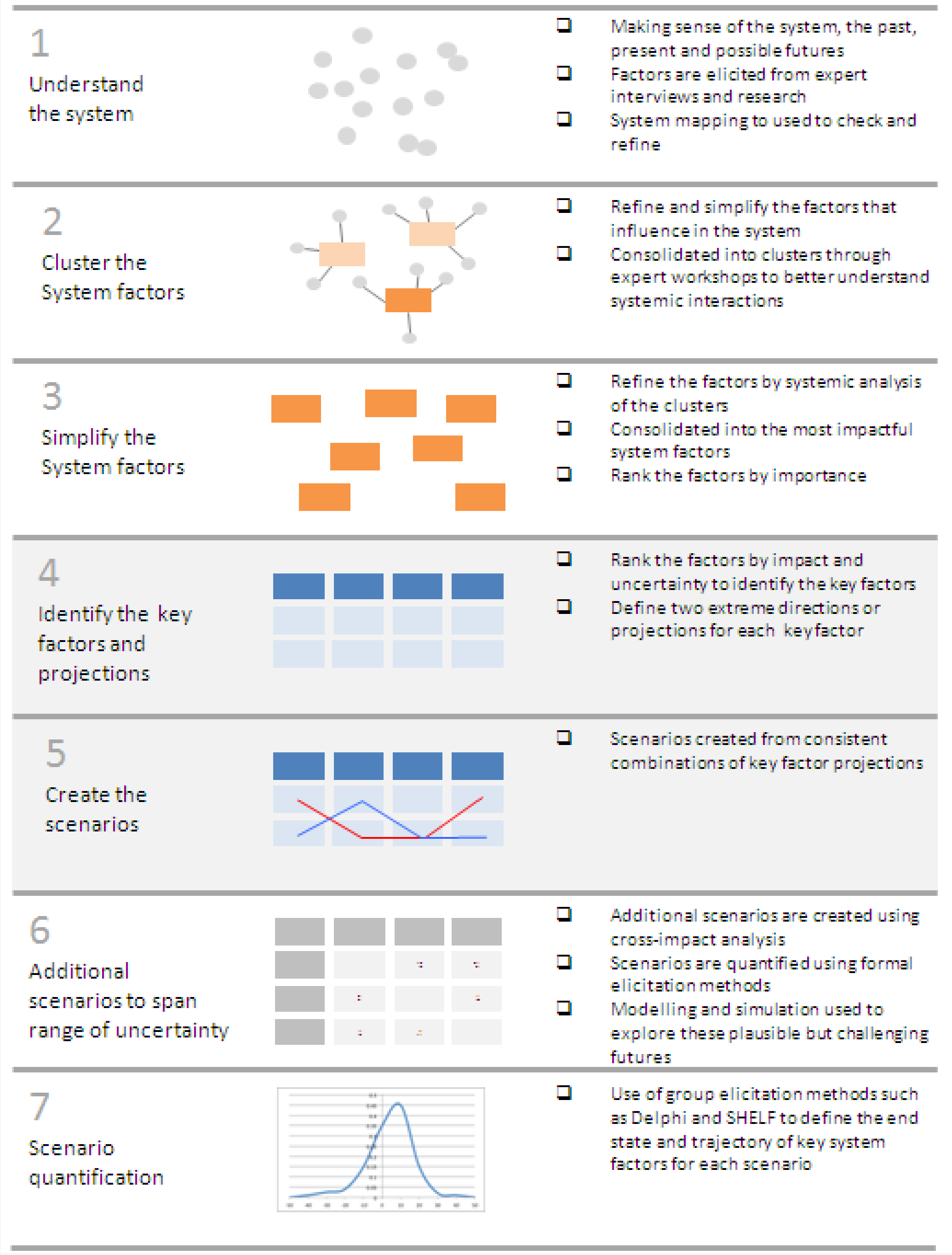
The CfWI approach to scenario generation is illustrated in Figure 2. The process is integral to the overall RWP framework (see Section 1.3), but can also be carried out in isolation if required.

The process incorporates the understanding of many stakeholders of the system under study through focused research, interviews and workshops. The CfWI has developed scripts for workshops, following the approach of group model building (Hovmand, et al., 2012). This ensures they are repeatable and that critical elements are carried out. Future technical reports will provide more information on the use of scripts for CfWI projects.

Each stage of the scenario generation process has clearly defined input and outputs. The insights from each stage increase understanding of the system under study and are circulated to the stakeholders participating in the process. This ensures transparency of the approach and stakeholder buy-in to the results generated. Figure 2 provides an overview of the approach.

Figure 2: Overview of the CfWI approach to scenario generation

The diagram below illustrates the CfWI scenario generation approach. System thinking methods are integrated with best practise in scenario generation to develop rich, consistent and plausible scenarios.



Source: The Centre for Workforce Intelligence

The following sections provide more information on the stages of the process, and relate them to a real application on the HS2035 project.

3.2 Horizon 2035 – Project overview

The CfWI was commissioned by the Department of Health to carry out the HS2035 programme of work. The purpose of the project is to consider different workforce futures for health, social care and public health 20 years from now. The focal question of the project is:

> 'Thinking up to the year 2035, what driving forces (both trends and uncertainties) may influence:
>
> - requirements of the future social care workforce?
> - workforce numbers, proportions, skills and competencies?'

The outcomes of this work will help ensure that health and care services can meet the challenges facing them, help to avoid boom-and-bust workforce planning outcomes, and ultimately provide better value for taxpayers. A key output from this project is a set of plausible scenarios for the future health, public health and social care workforce.

The scenario generation phase of the project began in October 2013. Initial research, which covers stage 1 of the process illustrated in Figure 2, was carried out prior to a cluster workshop. The cluster workshop held in November 2013 grouped the driving forces (stage 2). The clusters were analysed prior to a scenario generation workshop held in January 2014. 29 sector representatives and experts attended the scenario workshop. The function was to refine the factors (stage 3), identify the key factors (stages 4) and create the scenario narratives (stage 5). The workshop resulted in the generation of six consistent scenarios. Following the workshop, the scenarios were written up, and additional scenarios were then developed for detailed exploration (stage 6). The final output of the scenario generation phase was a report detailing the six scenarios (pending publication) and this technical paper describing the approach in greater detail.

3.3 Stage 1 – Understand the system

In order to develop consistent scenarios, the system and the environment that the system functions in must be clearly defined and understood. This ensures that as the scenarios are developed they take into account the cause and effect relationships that drive system behaviour. This includes exploration of historic trends and events that can be used to explain how the system evolved to its current state.

In addition, it is important to explore the potential challenges, opportunities and likely future developments that could influence the system under study. These can include technological, economic, environmental, political, social and ethical influences on an unfolding future.

A key output of this stage is fully defined set of system factors. Factors can be quantities (facts like number of people in a workforce) that describe a system, or subjective (qualitative) measures such as 'happiness'. They are linked to each other through cause-and-effect relationships. A change to a factor may influence one or more linked factors in the system. The impact of changing a factor on related factor may take time to manifest. Therefore, changing a factor may directly, or indirectly, have an eventual impact on the workforce demand and/or supply.

The stage 1 activities are generally carried out in the horizon scanning phase of the RWP framework (see Section 1.3), and the outputs are reports and web based analysis.

Horizon 2035 process

The CfWI has developed an extensive set of ideas[3], clusters, scenarios and big picture challenges that describes how the health and social care system functions, and the potential future challenges that may be faced. These were collated from a series of reports as summarised below:

- 365 ideas taken from the CfWI Horizon Scanning Hub (CfWI, 2013f)
- 70 clusters and 38 scenarios taken from CfWI scenario workshops
- 11 challenges taken from the CfWI's Big Picture Challenge (CfWI, 2013e).

Each of the ideas, clusters, scenarios and big picture challenges were examined and decomposed into 103 fully defined factors. This process is described in *Technical paper 6* (CfWI, 2013d).

In addition to the factor analysis, the key trends and changes that have occurred in the health and social care system over the last 20 years were documented, including time series data (CfWI, in press).

3.4 Stage 2 – Cluster the factors

The purpose of stage 2 is to refine the set of factors established in stage 1, explore plausible directions of travel for the system and identify gaps in understanding.

A cluster is a coherently defined set of factors and driving forces linked through cause-and-effect relationships that describe an aspect of the system under investigation. Assembling clusters from the system factors developed in stage 1 is a collaborative exercise that allows extreme, but plausible narratives to be assembled which conform to the underlying relationships that drive system performance. The clusters may also help to identify gaps in the set of factors developed in stage 1, for example where participants create new factors to support their reasoning.

Horizon 2035 process

Four workshops were held in November 2013 to create clusters that described fundamental dynamics affecting the health care, social care, public health sectors, along with the whole system. The workshops attracted over 50 stakeholders from across these sectors.

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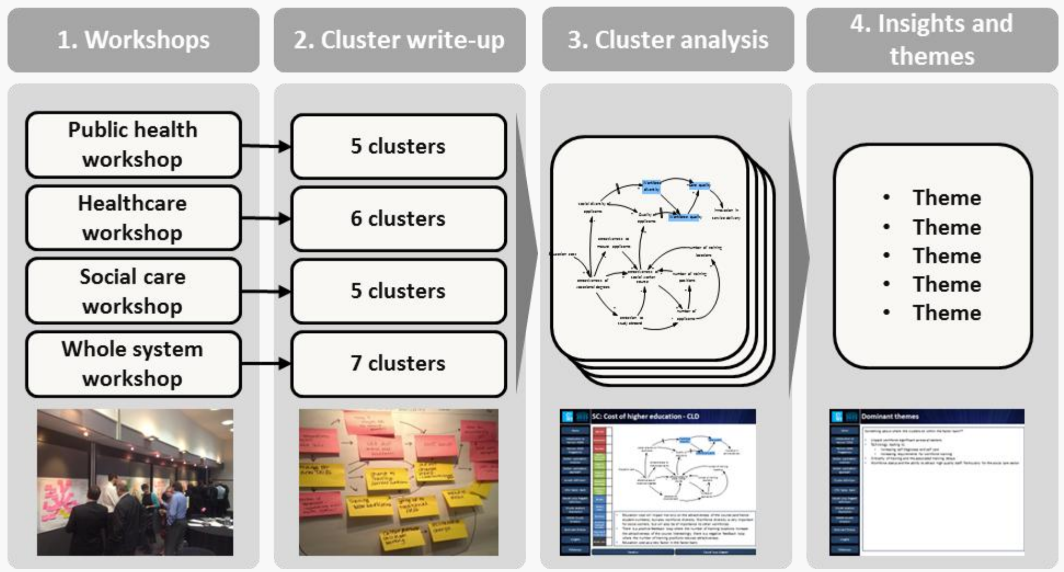
[3] An idea, as identified through horizon scanning, is a narrative that describes a potential future situation that would have an impact on the demand and/or supply of the health and/or social care workforce. The impact of the idea to the system may be detrimental (a threat) or beneficial (an opportunity) or a combination of both. Whether the impact is viewed as beneficial or detrimental will be dependent on the perspective of the stakeholder group. A fully defined idea is composed of a set of historical trends and/or events that may indicate that the situation is occurring, and a set of potential future trends and/or events that represent the impact to the system of the idea. The trends and events can be related to the system factors. A fully defined idea will have a likelihood of occurrence of the possible future it defines.

The clusters were documented in a series of written reports, capturing the story as told by the participants and the plausible but extreme outcomes. Each cluster was also documented using causal loop diagrams to capture the underlying cause and effect relationships that drive behaviour. The causal loops were then compared to derive common themes and drivers of wider system behaviour, and to identify additional factors for further analysis. The process for the HS2035 project is illustrated in Figure 3.

Figure 3: HS2035 cluster process

The diagram below illustrates the stages carried out in stage 2 of the scenario generation process for the HS2035 project.



Source: The Centre for Workforce Intelligence

Each of the clusters can be considered as a fragment or element of scenario for a particular sector or the whole system. This multi-level approach to scenarios is considered in more detail in Section 6.

The process enabled the list of factors to be refined, and an additional six factors were defined and added to the list, resulting in a total set of 109 system factors for consideration in the next stage of the process.

3.5 Stage 3 – Simplify the factors

The output from stages 1 and 2 can be an extensive set of factors that need refining prior to use in the generation of scenarios. We are interested in identifying those factors that are most important to the system understudy, in terms of those that have greatest impact and/or those about which there is great uncertainty about how they may evolve over time.

The list can be refined and simplified through the following actions.

- Undertake a systemic analysis of the influences of each factor, for example by developing an influence matrix (Vester, 2012, pp.219-230). The influence matrix describes the strength of the influence between all connected factors. Vester developed his approach to focus attention on the critical aspects of a system – those factors that have the greatest influence over system evolution. The method is reviewed In *Technical paper no.6* (CfWI, 2013d).

- Review those dominant themes and factors from the cluster analysis carried out in stage 2.

- Elicit stakeholder views regarding the most impactful and important system factors.

Horizon 2035 process

Stage 3 was carried out prior to and during the scenario generation workshop, which was held in January 2014 with 29 representatives from the health and social care system.

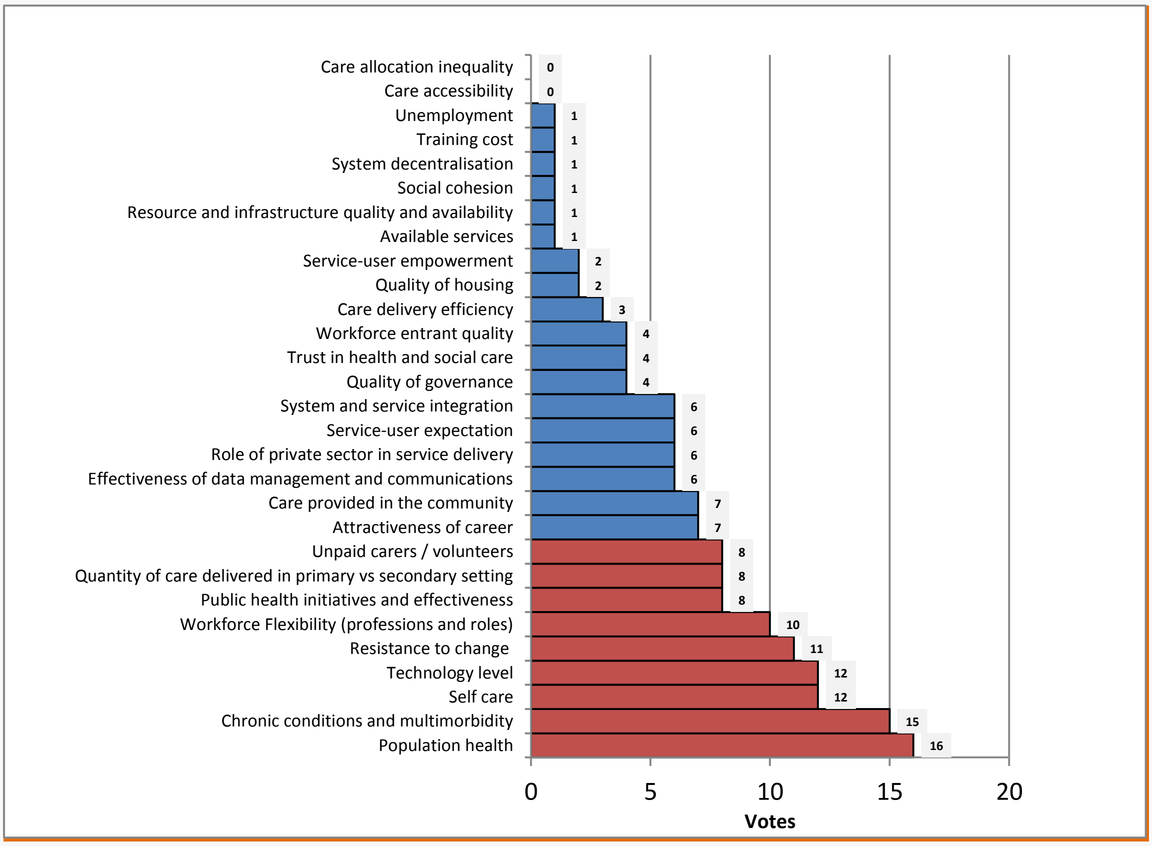
The initial stage of the factor simplification was to reduce the set of 109 factors to a more manageable set of 32 factors for the scenario generation workshop. Of the 32 factors, three were considered as external to the system under consideration (economy, population and environment). These are part of all scenarios.

The factor list was refined achieved through identification of those factors that cut across several clusters, analysis of system maps, and a series of internal reviews that successively consolidated lower-level factors into higher-level ones. All changes were tracked so that selected factors could be decomposed into their sub-factors.

The factors were ranked by the participants at the workshop in terms of their importance to the focal question (for example, the most significant effect, or the ability to tip the future in one direction or another). This ranking is shown in Figure 4.

Figure 4: HS2035 factor importance chart

The diagram below shows the voting for each of the 29 factors. Selected factors for scenario generation are highlighted in red.



Source: The Centre for Workforce Intelligence

This voting reduced the list of 29 internal factors to nine factors for scenario creation.

3.6 Stage 4 – Identify the key factors and projections

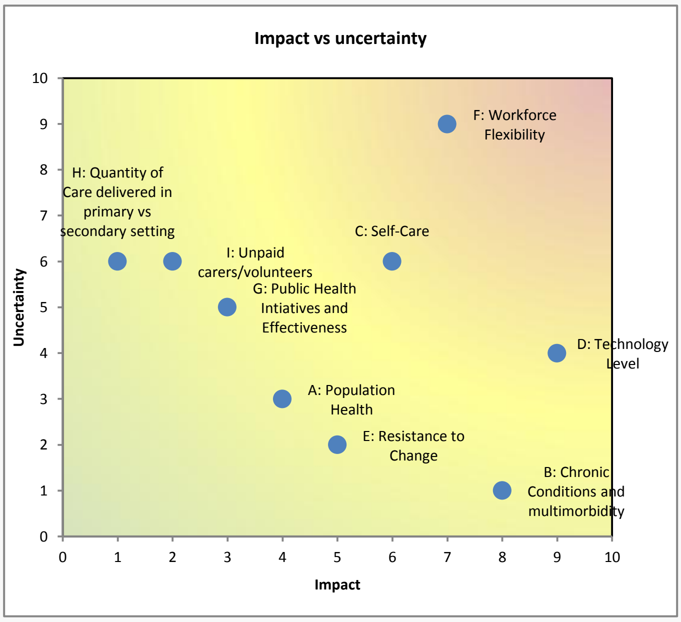
The purpose of stage 4 is to identify the key factors that will be used to create the scenarios. A key factor is a factor that has a large influence on the system, and/or where its future condition is highly uncertain. Each key factor may have a number of future projections, for example the economy may recover strongly, have weak growth, remain steady, or decline. Scenarios are then constructed from consistent combinations of key factors and their projections. For effective scenarios the factor projections need to be sufficiently different, have a strong impact on the focal questions but still be plausible. However, the more projections, the greater the number of factor combinations that need to be considered. Hence the number of projections considered is usually quite small, typically no more than five.

Horizon 2035 process

Workshop participants were asked to form groups and brainstorm two extreme or opposite resolutions by 2035 for each of the nine factors. Groups then reported back on the results, with attention being given to the impact of each factor on the focal question, and the uncertainty of direction of outcome. When all groups had reported participants were asked to vote on the impact and uncertainty of each factor. The results of the voting are shown in Figure 5.

Figure 5: HS2035 key factor identification

The diagram below shows impact uncertainty voting for the nine key factors.



Source: The Centre for Workforce Intelligence

Factors in the top right-hand corner are high uncertainty and high impact, so are critical for scenario generation. The top three factors from the voting were (1) workforce flexibility, (2) self-care and (3) level of technology. The fourth factor to be included for scenario generation was the economy.

3.7 Stage 5 – Create the scenarios

A scenario is a description of a possible future situation including the paths of development that may lead to that future situation. It is based on thinking about how the key factors change over the timeframe of interest.

Scenario consistency is of great importance. Each factor and its future outcome or projection needs to consistent with the projections of all other factors. Consistency is explored in greater detail in Section 4 of this report. Methods for checking consistency include the use of specialist software, often combined with group elicitation of consistency.

Following creation of a set of key factors and consistent projections of the factors over the time frame, the scenario narrative or storyline can be created and refined. Aspects to consider in the narrative include:

- creating end states for the key factors
- expanding the scope of the scenario to bring in the most important factors identified in stage 4
- developing a timeline for the events and activities that lead to the end state
- identifying those stakeholders that may be critical, oppose change or are at risk of being marginalised
- giving the scenario an evocative name that encapsulates the scenario as a whole.

Scenario building is an iterative process that is best done in a group environment so that different stakeholder perspectives can be incorporated. Following the creation of the scenario narratives they are written up and shared with the relevant stakeholders for comment.

Horizon 2035 process

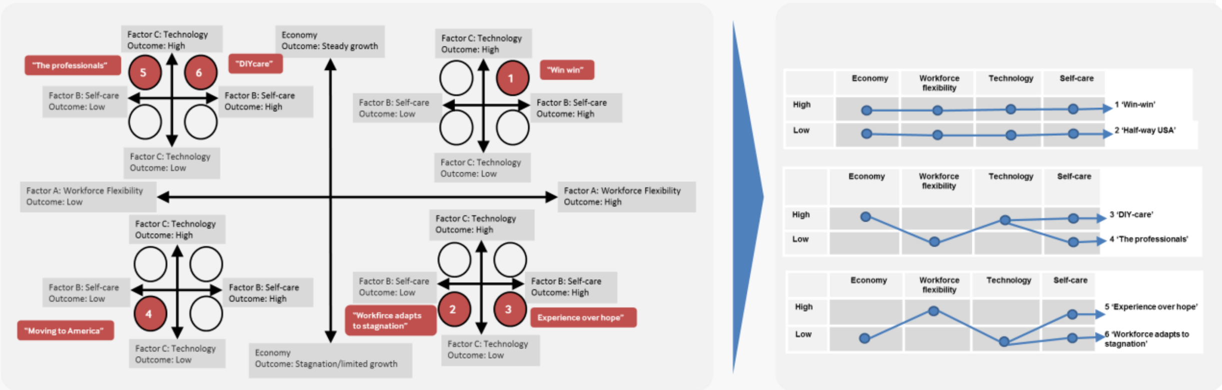
Stage 5 continued on from stage 4 at the January 2014 workshop, with the 29 sector representatives and experts.

Four factors were identified in stage 4 as being the most important for scenario creation. This is too large a number of factors for exploratory scenario generation in a workshop, as there would be too many combinations for participants to consider at once. Classical exploratory scenarios are generated around two axes or key uncertain factors, i.e. a single 2 x 2 matrix. For HS2035 a nested matrix approach was used (National Parks Service, 2013, pp. 38-40), where a 2 x 2 matrix is placed within a second 2 x 2 matrix. This has the potential to create 16 scenarios, but in practice some combinations will be inconsistent, reducing the total number.

Workshop participants worked in groups to ascertain which combinations of projections for the four key factors were consistent, and therefore relevant for development into scenarios. Figure 6 shows the consistency matrix as developed by the stakeholders, and the combinations of the key factor projections used as the starting point for the scenarios.

Figure 6: HS2035 consistent scenario development

The diagram gives two views of the consistency matrices developed as part of the HS2035 scenario generation workshop. The matrices enabled six consistent scenarios to be identified, which were then worked up into described futures for the health and social care sectors.



Source: The Centre for Workforce Intelligence

The consistent combinations of the key factors allowed the identification of six consistent scenarios[4]. The stakeholders worked in groups to develop the scenario narratives. The activities included:

- developing a full definition of the final system state in 2035
- describing the time line of events and activities that lead to the end state
- considering the changes to each of the 32 system factors provided to the stakeholders in stage 3
- identifying likely stakeholder responses to the scenario events and activities
- discussing the scenarios in a story telling session with all workshop participants.

Following the event, the scenarios were written up and circulated back to the participants for confirmation that they were representative of the workshop discussions.

[4] Section 4 describes methods that can be used to determine scenario consistency using cross-impact analysis, and provides a sample calculation for the key factors form the HS2035 scenario generation.

3.8 Stage 6 – Additional scenarios to span a range of uncertainty

A key goal of the narrative scenarios is to provide plausible strategic challenges that stakeholders may need to manage in the future. They also provide context for detailed quantitative models that can be used to test policy.

It is acknowledged that scenarios developed during this process will not encompass all possible futures as there are an infinite number of ways that the system could potentially evolve. However, it is important this uncertainty is recognized and explored. The additional scenarios can be discovered using cross impact analysis to generate consistent sets of scenarios. Details about scenario consistency are provided in Section 4.

Horizon 2035 process

3.9 Stage 7 – Scenario quantification

The process of generating additional scenarios is currently being tested, using the cross impact method described in Section 4. The findings will be reported in a future CfWI technical paper.

The scenarios generated by the previous stages are qualitative scenarios. Those generated at the workshops are documented as detailed narrative stories to capture the attention and promote debate. Scenarios need to be quantified to enable simulation models to be built that can be used to carry out policy analysis, as part of the robust workforce modelling framework. This requires parameters that are inherently uncertain to be estimated. These parameters typically vary from scenario to scenario. This is typically done with judgements from experts using a formal and defined protocol. Details about elicitation methods are provided in Section 5.

Further information about the CfWI's approach to modelling and simulation using system dynamics is given in *Technical paper 8* (CfWI, 2014b), and policy analysis in *Technical paper 9* (CfWI, in press).

Horizon 2035 process

The quantification process is currently being refined and tested as described in Section 5. The findings will be reported in a future CfWI technical paper.

4. Ensuring scenario consistency

A critical part of scenario development is to produce compelling scenario stories that are comprehensive and detailed enough to be believable, but also are internally consistent. To give an example, a future where the economy is not doing well but health research is very well funded may not be fully consistent if these are the main factors being considered. Being able to determine the consistency of a scenario allows the plausibility of the scenario to be assessed. A study by Schweizer and Kriegler (2012) which explored the consistency of emissions scenarios found that of the scenarios examined, 77 per cent were not fully internally consistent. It is important to note that consistency is not a measure of likelihood.

There are a variety of methods for producing consistent scenarios, and the scenario generation method as described in Section 3 checks the consistency of the scenarios prior to creating the scenario narrative. This section provides more detail about how scenario consistency can be formally assessed and quantified.

4.1 Information approaches to scenario consistency

In the exploratory scenario method using intuitive logic (see Section 2.1), scenarios are typically constructed around two key axes. It is therefore relatively straightforward through discussion to determine whether the factor pairs are consistent.

As previously noted, Figure 6 illustrates a sample consistency matrix developed by workshop participants around four key factors from the HS2035 project. Here, the scenarios highlighted in red were chosen as the most consistent, based on informal discussions. Once the number of factors being explored increases past four and there are more than two future projections, the number of combinations rapidly increases beyond the point where informal methods can be used. This is where the analytical approaches discussed below are needed.

4.2 Analytic approaches to scenario consistency

A number of analytical methods, such as cross impact analysis, morphological analysis and cross impact balance analysis have been used to assess scenario consistency and generate consistent scenarios. These methods allow the interactions of large sets of factors to be explored, and a consistent set of factor changes to be determined.

Cross-impact analysis (Gordon, 2009) has been used in a variety of forms for analysing the interactions between events and variables in systems. In the original form the probability of pairs of events occurring are sought, and scenarios constructed from the most likely sets. Table 1 illustrates another form of this approach, where the relationships between pairs of factors are visualised as a matrix. A positive sign between factors A and B means that factor A supports factor B, and a negative sign means that it hinders. A blank means there is none or a neutral interaction. Analysis of the matrix can help uncover relationships that might otherwise have been overlooked, or unexpected strong or weak influences.

Table 1: Example cross impact matrix

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1		+	+	
Factor 2			-	+
Factor 3				-
Factor 4	+			

Source: The Centre for Workforce Intelligence

The matrix can be used to consider how factors influence each other and in what direction, a key step for ensuring scenario consistency.

Morphological analysis uses a similar pair-wise approach (Ritchey, 2009) but rather than factors or events focuses on the *parameter space* of the problem, and in particular on their *states*. This is equivalent to the key factors and their projections as discussed previously in Section 3.6. A cross-consistency matrix is used to compare all the combination of parameter states, judging whether they are consistent or inconsistent. Table 2 provides an example of morphological analysis, again using four factors, each of which has up to five projections. The highlighted cells illustrate one consistent combination of factor and projections (P1.2, P2.4, P3.3, and P4.1). Typically there will be several sets of varying degrees of consistency.

Table 2: Example morphological analysis

Factor 1	Factor 2	Factor 3	Factor 4
P1.1	P2.1	P3.1	P4.1
P1.2	P2.2	P3.2	P4.2
P1.3	P2.3	P3.3	P4.3
	P2.4		P4.3
	P2.5		

Source: The Centre for Workforce Intelligence

The approach used for the HS2035 project to confirm scenario consistency is described below. It is called cross-impact balance analysis (CIB), which is a variant of cross-impact analysis (Weimer-Jehle, 2006). It uses a similar pair-wise approach with a qualitative scale, but divides judgements into groups where the impacts of one factor and all its projections are judged against all the projections of another factor. These groups are scored for consistency, and scenarios are generated from consistent combinations. Figure 7 illustrates the approach. For further information see Weimer-Jehle (2013).

Figure 7: Cross-impact balance analysis

This is a hypothetical example cross-impact balance matrix from the ScenarioWizard manual.

Cross-Impact Matrix "Somewhereland"	A.Gov A1 "Patriots party"	A2 "Prosperity party"	A3 "Social party"	B.FoP B1 Cooperation	B2 Rivalry	B3 Conflict	C.Eco C1 Shrinking	C2 Stagnant	C3 Dynamic	D.W D1 Balanced	D2 Strong contrasts	E.SCo E1 Social peace	E2 Tensions	E3 Riots	F.SoV F1 Meritocratic	F2 Solidarity	F3 Family
A. Government:																	
A1 "Patriots party"				-2	1	1	0	0	0	0	0	-2	1	1	0	0	0
A2 "Prosperity party"				2	1	-3	-2	-1	3	-2	2	0	0	0	2	-1	-1
A3 "Social party"				0	0	0	0	2	-2	3	-3	2	-1	-1	-2	2	0
B. Foreign policy:																	
B1 Cooperation	0	0	0				-2	1	1	0	0	0	0	0	0	0	0
B2 Rivalry	0	0	0				0	1	-1	0	0	1	0	-1	0	0	0
B3 Conflict	3	-1	-2				3	0	-3	0	0	3	-1	-2	-2	1	1
C. Economy:																	
C1 Shrinking	2	1	-3	0	0	0				-2	2	-3	1	2	0	0	0
C2 Stagnant	-1	2	-1	0	0	0				0	0	0	0	0	0	0	0
C3 Dynamic	0	0	0	0	0	0				-2	2	3	-1	-2	0	0	0
D. Distribution of wealth:																	
D1 Balanced	0	0	0	0	0	0	0	0	0			3	-1	-2	-2	1	1
D2 Strong contrasts	0	-3	3	0	0	0	0	0	0			-3	1	2	2	-1	-1
E. Social cohesion:																	
E1 Social peace	0	0	0	0	0	0	-2	-1	3	0	0				2	-1	-1
E2 Tensions	0	0	0	-1	0	1	1	1	-2	0	0				-1	0	1
E3 Riots	2	-1	-1	-3	1	2	3	0	-3	0	0				-2	-1	3
F. Social values:																	
F1 Meritocratic	0	3	-3	0	0	0	-3	0	3	-3	3	-2	1	1			
F2 Solidarity	1	-2	1	0	0	0	-1	2	-1	2	-2	2	-1	-1			
F3 Family	0	0	0	0	0	0	-1	2	-1	1	-1	2	-1	-1			
Scenario assumptions:		↓		↓					↓	↓		↓			↓		
Balances	0	3	-3	2	1	-3	-9	-1	10	-7	7	4	-1	-3	2	-1	-1
Maximum:		↑		↑					↑		↑	↑			↑		

The impact score of a variant

The impact balance of a descriptor

Source: Weimer-Jehle (2013, p.11)

CIB analysis has been used in an interesting study (Schweizer and Kriegler, 2012) of scenarios published in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). While the SRES did identify internally consistent scenarios, not all scenarios featured in SRES were equally internally consistent. Of particular interest was that there were sets of scenarios featuring carbon-intensive futures that were found to be highly robust and consistent, but were missing. Findings of this nature are helpful in identifying scenarios which might otherwise be ignored due to political sensitivities and influences.

4.3 CIB analysis applied to Horizon 2035 key factors

The HS2035 project generated six scenarios based on two projections for four key variables (See Section 3.7). Based on the number of factors and projections, there are 16 (2^4) possible permutations that could be used to define the scenario dimensions. Following the scenario generation workshop, the CIB method was used to check the scenarios produced by workshop participants for consistency. The calculation is presented below to illustrate the use of CIB:

The scenario key factors and their projections for HS2035 were as follows:

- economy – strong or weak economic situation in England
- technology – high or low level of technology availability
- self-care – high or low level of self-care by the population
- workforce flexibility – high or low level of flexibility in the workforce.

Following the workshop, pairwise judgements were made of the influence between the factors using the following quantitative scale:

- strongly restricting influence (-3)
- moderately restricting influence (-2)
- weakly restricting influence (-1)
- no influence (0)
- weakly promoting influence (+1)
- moderately promoting influence (+2)
- strongly promoting influence (+3).

The results of the pairwise analysis are summarised in Table 3.

Table 3: Cross-impact balance matrix from HS2035 workshop

	A		B		C		D	
	A1	A2	B1	B2	C1	C2	D1	D2
A. Economy								
A1 – Strong			+3	-2	-1	+2	+1	+1
A2 – Weak			-2	+2	+2	-1	+1	+1
B. Technology								
B1 – High	+2	-1			+3	-2	+1	-1
B2 – Low	0	0			-2	+2	0	0
C. Self-care								
C1 – High	0	0	+1	-1			0	0
C2 – Low	0	0	-1	+1			0	0
D. Workforce flexibility								
D1 – High	0	0	0	0	0	0		
D2 – Low	+1	0	0	0	0	0		

Source: The Centre for Workforce Intelligence

A detailed explanation of each judgement group is given in Figure 8.

Figure 8: Example cross-impact balance analysis using HS2035 key factors

Pairwise judgements were made of the influence between the key factors identified during the HS2035 workshops, namely **economy**, **technology, self-care** and **workforce flexibility**.

Direction influence of economy on technology

A strong economy may mean that more resources are available to support a high level of technology. It is not consistent with a low level of technology availability. A weak economy is not consistent with a high technology use, but is consistent with low-level usage.

Economy	Technology: High	Technology: Low
Strong	+3	-2
Weak	-2	+2

Direct influence of technology on economy

High technology is consistent with a strong economy, and not with a weak one. Low levels of technology were assumed to make little difference given the overall size of the economy.

Technology	Economy: Strong	Economy: Weak
High	+2	-1
Low	0	0

Direct influence of self-care on workforce flexibility

The direct influences of self-care on workforce flexibility were thought to be would be weak, and arguments were made either way. Consequently a zero influence was assumed.

Self-care	Workforce flexibility: High	Workforce flexibility: Low
High	0	0
Low	0	0

Direct influence of economy on self-care

A weak economy could drive people towards a higher-level of self-care, but is not consistent with a low-level. A strong economy means that people may not need as much self-care, and is inconsistent with a high-level.

Economy	Self-care: High	Self-care: Low
Strong	-1	+2
Weak	+2	-1

Direct influence of technology on self-care

Giving consideration to self-monitoring and diagnosis, a high-level of technology would support self-care, and is not consistent with a low-level. Conversely, high-levels of self-care are less likely without technology.

Technology	Self-care: High	Self-care: Low
High	+3	-2
Low	-2	+2

Direct influence of self-care on technology

Self-care was considered to weakly promoting technology.

Self-care	Technology: High	Technology: Low
High	+1	-1
Low	-1	+1

Direct influence of economy on workforce flexibility

The influence of the economy of workforce flexibility is a difficult one and no firm conclusions were drawn. All combinations were though to be plausible.

Economy	Workforce flexibility: High	Workforce flexibility: Low
Strong	+1	+1
Weak	+1	+1

Direct influence of technology on workforce flexibility

Technology does not have much influence on workforce flexibility, although a high-level of technology could support and improve flexible working.

Technology	Workforce flexibility: High	Workforce flexibility: Low
High	+1	-1
Low	0	0

Direct influence of workforce flexibility on self-care

An inflexible workforce was thought to be consistent with a high-level of self-care, but all other influences are zero as it was less clear as to the direction.

Workforce flexibility	Self-care: High	Self-care: Low
High	0	0
Low	+1	0

Source: The Centre for Workforce Intelligence

Comparison of the Horizon 2035 CIB analysis with the scenarios from the workshop

The analysis was carried out using ScenarioWizard (Weimer- Jehle, 2013) to support the process. Although a CIB analysis can be conducted on paper or using a spreadsheet, this software greatly reduces the time required.

The results of the CIB analysis are summarised in Table 4. Since the scenarios were derived from consideration of four key factors in the system under investigation, rather than the full set of nine factors, the consistency constraints were relaxed[5] to permit a larger set of scenarios to be generated.

Scenarios labelled A to F were selected by workshop participants from the 16 available ones (four factors with two projections) after discussion and identification of the less consistent ones.

Two scenarios (labelled as missing) were additionally identified as consistent.

Table 4: Cross-impact analysis of HS2035 workshop scenarios

Workshop scenario	Consistency score	Economy	Technology	Self-care	Workforce flexibility
A	+2	Strong	High	High	High
B	0	Weak	Low	Low	Low
C	-1	Weak	Low	High	High
D	-2	Strong	High	Low	Low
E	0	Weak	Low	Low	High
F	-2	Strong	High	High	Low
Missing	-2	Strong	High	Low	High
Missing	-1	Weak	Weak	High	Low

Source: The Centre for Workforce Intelligence

This analysis confirms that the scenarios selected at the workshop using an intuitive logics approach were consistent.

Work is continuing as part of the HS2035 project to generate additional consistent scenarios for modelling and analysis using the full set of nine system factors.

[5] This is done in ScenarioWizard by selecting the 'weak consistency' option.

5. Eliciting uncertain scenario parameters

The scenarios used by the CfWI for strategic workforce planning need to be quantified to enable simulation models to be built that can be used for policy analysis[6]. This requires parameters that are inherently uncertain to be elicited. This requires input from experts using a formal and defined protocol. The CfWI currently uses protocols such as Delphi to obtain this information.

Quantification of scenario parameters is powerful since it informs decision-making. However, it carries risks, especially when combined with a mathematic model, as it may suggest a certainty and precision that does not exist, and may hinder communications with audiences who are not numerically literate. Where factors are inherently uncertain, they should not be represented by a single value, but typically are given a probability distribution representing their uncertainty.

Methods are needed to elicit the value of parameters where there is lack of data and considerable uncertainty. Expert judgements are often used for formal methods such as a Delphi consensus approach. Delphi is currently the main method used by the CfWI for quantification. However, not all participants are comfortable with making judgements where there is limited understanding and information.

This section provides a brief review of the Delphi method and presents alternatives which are currently being investigated.

5.1 The Delphi method

The Delphi method is a systematic consensus process for collecting and refining the knowledge of a group of experts (Linstone and Turoff, 2002). It is an iterative process where experts provide their individual estimate for the parameter under consideration, together with their reasoning. The facilitator then anonymously shares these answers and reasons with all the other participants in the exercise. They then have the opportunity to revise their estimates over two or more rounds.

The CfWI currently uses an online Delphi questionnaire to assist in quantifying uncertain scenario variables. The CfWI (2013c, pp. 45-46) describes the questions and responses for a recent modelling exercise.

5.2 Issues with the Delphi method

Although the Delphi method is widely used and documented it is not straightforward. The key assumption is that anonymity is preferable to group discussion, since social interactions may influence the responses. Of course, it may be that it in some situations the opportunity for a group discussion would actually improve the responses of the group. Attention must be given to how the

[6] More detail about the CfWI's approach to policy analysis is given in CfWI Technical Paper 9 (CfWI, in press).

exercise is structured and conducted, and considerable time and effort is often required. Tapio (2002, pp. 87-92) lists eight problems with the Delphi method:

- biased selection of the panellists
- disregarding organisational opinions
- forgetting and not exploring disagreements
- ambiguous questionnaires
- oversimplified structured inquiry which does not leaving room for new ideas
- feedback reports without analysis
- forgetting the arguments
- lack of theory.

The standard Delphi method may underrepresent uncertainty, since participants are asked for their expected or 'best-guess' estimates, and the distribution of the medians underestimates the true uncertainty.

5.3 New elicitation methods to supplement the Delphi approach

Delphi belongs to a class of methods called mixed approaches, which joins behavioural aggregation where experts interact, with mathematical combining of judgements. Anonymity of experts is a characteristic of Delphi intended to reduce social and political pressures and influences. However, this is at the expenses of participants being able to have open debate to achieve consensus. This is a feature of pure behavioural aggregation, for example the Sheffield elicitation framework (SHELF) (O'Hagan, 2013). This has a well-defined protocol to correct likely biases and supports knowledge sharing without allowing the group to be dominated by any individual. The SHELF approach is being used for the HS2035 project, supported by Professor Tony O'Hagan. This will involve a panel of no more than five to eight experts. Once 'trained' in the approach it may be possible to apply the SHELF methodology to an online Delphi to increase the number of parameters that can be elicited. This is a new idea that we plan to test.

5.4 Improving the Delphi approach used for CfWI strategic studies

There are situations where the standard Delphi approach is useful. Unlike the SHELF method, little training is needed for participants, and a large number of variables can be quantified. However, the drawbacks listed previously need to be addressed.

A workshop approach is being investigated as a replacement for online Delphi. This will be scripted in a similar way to the scenario workshops. Current thinking is that this could be divided into two sessions. The first session would be a cluster workshop (see Section 3.4) to explore the system and understand the level of uncertainty. The second session, which might be held on the same day, would be facilitated workshop. Following a group discussion of the cluster workshop outputs, electronic voting would be used to elicit values for the parameters under investigation. Each round of voting would be followed by a group discussion and then another vote. The thinking is that the discussion process is more valuable than participant anonymity in areas where difficult judgements have to be made, for example the future health needs of the population. It may help to avoid problems that have been experienced in the past around understanding the questions, especially when values are being sought across a number of scenarios.

The selection of participants in an elicitation exercise is always difficult and could be improved. Participants typically need to be ‘expert’ in the area of inquiry. There needs to be a sufficient spread so that different viewpoints are represented. A related problem is that the client often believes that more participants in the elicitation exercise will lead to greater accuracy. This is not best practice. More participants may lead to more debate and dissent, and does not correspondingly increase accuracy. Further research is required on the appropriate size and composition of the elicitation panel.

The SHELF method and online Delphi method are in the process of being tested in the HS2035 project. We are also testing the Delphi workshop approach in a number of current workforce reviews. The findings will be reported in a future technical paper.

5.5 Communicating uncertainty

Presenting the degree of uncertainty in model outputs is critical; ignoring uncertainty does not make it go away.

> ‘Many technical professionals have argued that one should not try to communicate about uncertainty to non-technical audiences... We do not agree. Non-technical people deal with uncertainty, and statements of probability, all the time. They don’t always reason correctly about probability, but they can generally get the gist.’
>
> Morgan et al. (2009, p.17)

It is unethical if clients needed to make significant decisions are presented with results without being made aware of the inherent uncertainty. It is equally unethical of the client if they do not ask about the degree of uncertainty. But such questions are both difficult to ask and to answer. As Lempert, Groves and Fischbach (2013) note:

> 'Ethically defensible policy judgments require examining arguments from multiple points of view. Such judgments also require close attention to their actual effect on social realizations, that is, on the lives people actually lead. Thus ethical judgment demands a reasonable level of due diligence towards assembling available evidence and using it to judge the consequence of proposed actions.
>
> Uncertainty can complicate this exercise of due diligence by proliferating the potential consequences that flow from an action and making differences in rankings of values or preferred outcomes more salient. Given this complexity, some type of formal process is often required to help people sort through the many combinations of values, attitudes toward risk, and consequences of different policy choices.'
>
> Lempert, Grove and Fischbach (2013, pp.20-21)

Where a single projection is to be presented, for example an expected forecast, a fan chart might be used to represent the uncertainty (Britton, Fisher and Whitley, 1998). However, when there are several different outputs to be presented, like demand and supply across five or six scenarios, the outputs can be confusing. In the case of workforce planning, we may be interested not just in the mismatch between demand and supply, but a range of other parameters including the pay bill and the age profile of the workforce.

Further research is needed into approaches for presenting such information, recognising the need to make decision-makers aware of the uncertainty, while avoiding information overload and possible confusion and misunderstanding.

6. Multi-scale scenarios

The Millennium Ecosystem Assessment (2005) defines a multi-scale assessment as: 'A process that incorporates at least two complete, nested, and interacting assessments, each with a distinct user group, problem definition and expert group'. Multi-scale scenarios build on this, where scenarios are developed at different scales – for example global, national and regional – and linked to a varying degree. Scenarios can be produced at different levels of scale for the particular situation under consideration. Example scales are geographic regions (global, national or local), timeframes (short, medium or long) or workforce groups (health system, profession, or specialty). A good example is the sub-global scenarios produced for the Millennium Ecosystem Assessment (2005, pp. 229-259) where a local assessment is nested within a regional assessment in a global assessment. This section discusses how the use of multi-level can improve the consistency of the scenarios generated by the CfWI for strategic workforce studies.

Multi-scale scenarios offer considerable potential in workforce planning, offering different perspectives and insights across the different levels or greater depth of analysis of the impact of policy options. For example, policies may have a different or even conflicting impact at different levels of scale, as may stakeholder responses.

Scenarios may be tightly or loosely coupled, as defined by Biggs et al. (2007), with advantages and disadvantages to both.

> ‘The advantage of multiscale scenarios are that they can, at least to some extent, take account of cross-scale feedbacks and differences in drivers and stakeholder perspectives at different scales. Based on our assessment of multiscale scenarios, we suggest that, if the aim is to engage stakeholders, loosely linked scenarios are generally more appropriate. Loosely linked multiscale scenarios tend to allow more freedom to explore the issues of concern to the stakeholders at each scale. In this case, any of the linking options identified above may serve as a bridging mechanism between stakeholders at different scales to understand the impact of decisions made at one scale on other scales. A major disadvantage of loosely linked scenarios is that the storylines are often inconsistent across scales and cross-scale interactions are not well accounted for. Tightly coupled cross-scale scenario exercises are more appropriate when the aim is to evaluate cross-scale processes and potential responses. We therefore suggest that tightly coupled cross-scale scenarios are most appropriate if the main objective is to further scientific understanding or to inform policy making with respect to an issue that has differential effects at different scales or has strong cross-scale interactions or feedbacks. Such fully coupled scenarios can include processes and perspectives necessary to allow an in-depth cross-scale analysis and the development of cross-scale institutional links. However, developing tightly coupled cross- scale scenarios requires a very large input of time, technical expertise, and financial resources, which should not be underestimated.’
>
> Biggs et al. (2007)

The advantages of developing multi-scale scenarios are that interactions in complex systems usually occur across different levels of scale. These interactions can be considered at varying levels of detail and consistency can be enforced between these levels. For example, for scenarios considering environmental futures, local climate change is influenced by regional and global climate, and local strategies for development and planning exist within regional and national policies. Scenarios should not only be internally consistent, but should be consistent at their level of scale. Higher-level scenarios frame the scope for the lower-level ones, increasing the overall coherence of the set. Effectively, the higher-level scenarios set the boundary conditions for the ones below.

As discussed previously, scenarios can be loosely or tightly coupled across the scales. For example, in a tightly coupled method, drivers and constraints from higher-level scenarios might be part of all lower-level scenarios. Similarly, workforce numbers at the top-level should be the sum of all numbers at lower-levels. In a more loosely coupled approach, there would be much more flexibility about which drivers to include or not. As a consequence, scenario narratives would be less constrained.

There are a number of approaches for developing multi-scale scenarios (Kok, Biggs and Zurek, 2007) which can be categorised as follows.

- Develop at a high-level and downscale to lower level scenarios.
- Develop at scenarios at a low level and upscale to the higher level.

- Develop scenarios independently and link afterwards.

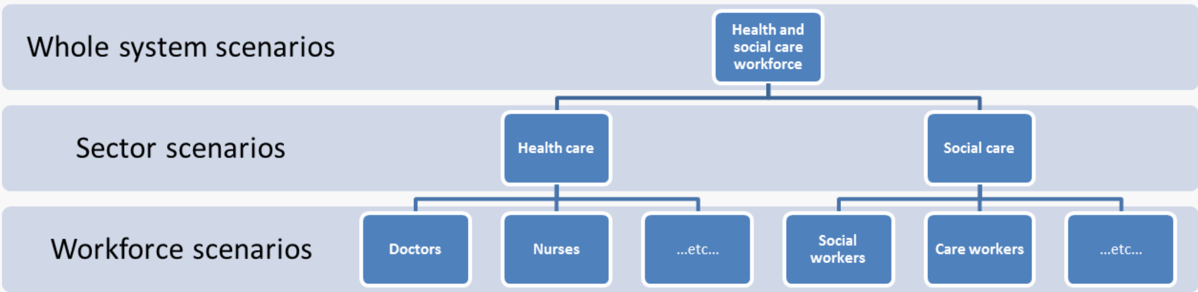
However, as Biggs et al. (2007) note: 'formal approaches for linking scenarios across multiple scales are not yet well developed or tested'.

6.1 Considering multi-scale workforce models

For workforce planning, the levels of scale might be the whole system (health, public health and social care), major workforce groups (health), or individual workforces (doctors). This is a hierarchical view of the health and social care workforces, as illustrated in Figure 9.

Figure 9: Health and social care workforce hierarchy

The diagram illustrates potential hierarchies that could be used for developing scenarios for the health and social care workforces.



Source: The Centre for Workforce Intelligence

The CfWI has developed scenarios at multiple levels of the hierarchy illustrated in Figure 9. For example, the HS2035 project has developed scenarios at the whole system and sector level. Many CfWI workforce reviews have developed scenarios that are at the workforce level of representation, for example general practice, dentistry, pharmacy, and psychiatry.

6.2 Multi-scale workforce models as applied to Horizon 2035

For the HS2035 project, separate scenarios were first developed at the sector level shown in Figure 9, i.e. for the health, public health and social care sectors separately. These were developed in the cluster workshops (see Section 3.2), and although not fully formed scenarios, the clusters are essentially mini scenarios that were relevant to a single sector. The clusters were informed by a set of factors structured according to the degree of influence workforce planners have over them. This influence is considered as being very low for the external factors such as economy or the environment or much higher for internal factors such as workforce quality. This list of factors and the extent to which we have control over them is discussed in *Technical report 6* (CfWI, 2013d). The sector specific clusters resulting from these workshops were then used to derive the key factors and their projections for scenario creation, as described in Section 3.6.

6.3 Creating an integrated scenario set for workforce planning

The CfWI has created over fifty scenarios for a number of strategic studies. Some of the scenarios are at the highest level (e.g. those from HS2035) and some are at the very lowest level (e.g. for specific professions such as dentists or pharmacists). The degree of consistency between these scenarios varies considerably. Quantitative modelling has been conducted for many of the lower-level scenarios to determine the potential future demand and supply for these workforces. However, because the scenarios are not linked or related in a systematic way, it is not possible to combine these separate workforce studies to generate more detailed system-wide insights. For example, a scenario that considers a change in the demand for doctors as a result of skill mix must also consider the impact on the other workforces in order to make recommendations that take into account the interconnected nature of the health and social care sector.

The CfWI is investigating ways of improving the consistency of the scenarios developed to date, and for future studies. CIB analysis will be used to determine the consistency of these scenarios and the findings will be analysed to distil system-wide insights. The findings will be published in a future technical paper.

7. Conclusions

The research and activities described in this technical paper produced the following substantive improvements to the scenario generation process.

- Horizon scanning is more tightly integrated with the scenario generation stage of the robust workforce planning framework. Systems thinking concepts have been used to structure and analyse the ideas contained in the horizon scanning hub, and to synthesise them for the scenario workshops.
- Scenario generation has been formalised. The original one-day workshop has been divided into a half-day cluster workshop and a full-day scenario workshop. Both are fully defined, scripted and repeatable.
- Systems thinking methods have been applied to the analysis of the system under investigation, for example the use of causal loop diagrams. The categorisation of factors by technology, economy, environment, politics, society and ethics (the TEEPSE framework) has been replaced by a more sophisticated taxonomy that provides greater separation between external and internal factors.
- A wider range of scenarios are now produced. The 2 x 2 matrix method has been replaced and scenarios are now generated across four main axes. Workshop participants now check potential factor combinations for consistency before proceeding to create detailed narrative scenarios.
- Formal methods have been introduced to check scenarios for consistency. The cross-impact balance method is used to confirm the consistency of workshop scenarios, and to generate additional scenarios for modelling using a larger number of factors. This provides a greater depth and richness for subsequent quantification and modelling.
- The quantification of scenarios has been recognised as needing improvement. We are working with Professor Tony O'Hagan on the use of the Sheffield Elicitation Framework (SHELF) to elicit probability distributions for critical uncertain parameters. Investigations are on-going to use this approach to improve the Delphi method. Further studies are underway into Delphi expert workshops.
- There is a need for a greater understanding of uncertainty. Current methods such as Delphi do not provide a true probability distribution, unlike approaches such as SHELF. The greater the criticality of a parameter, i.e. the higher the impact, the more effort is required to understand the nature of uncertainty around the values it could take.
- Scenarios are being produced at different levels of scale. Sector-wide scenarios for health, public health and social care were upscaled to produce six whole system scenarios. Multi-scale scenarios offer considerable potential to improve the current set of over 50 scenarios, and to ensure that future scenarios are both internally consistent, and coherent at their level of scale.

The improvements to the scenario process directly impact the quality of advice that the CfWI provides. Having a larger set of consistent scenarios exposes decision-makers and workshop participants to a greater range of ideas, challenges and opportunities for the future. Better quantification of scenarios directly leads to more accurate model outputs for policy analysis and recommendations.

7.1 Areas for further research

The following areas are currently being investigated:

- generation of additional scenarios for the HS2035 project using the CIB method across all nine key factors
- conducting a consistency analysis of the CfWI set of scenarios using the CIB method
- use of the SHELF for quantification of critical HS2035 scenario parameters, and testing the application of a version of Delphi that elicits probability judgements
- testing a Delphi expert workshop approach as a potential replacement to an online Delphi survey
- production of guidance for the appropriate elicitation method to use according to the nature of the investigation, and also for the selection of expert panels
- research on multi-scale scenarios, starting with production of a set of high-level scenarios to provide the context for the generation of more detailed workforce scenarios
- research into ways of presenting uncertainty to decision-makers.

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