

ABSTRACT

This paper surveys how, why, and with what effects organizations whose activity is centred on the work of the natural sciences and their application to societal issues, and whose core staff are natural scientists -often working with a positivist epistemology- use scenario planning. Based on three cases, we research how the scenario planning methodology was utilized, why it was selected, and with what effects. Our research suggests that scenario planning can be deployed to enhance the social engagement which science requires to operate; and which enables science and the organizations which support it to justify the value which science creates and thus to help secure its funding and restate and render explicit what the purpose of such organizations is. This paper contributes to scenario planning scholarship by extending the type of organizations which can benefit from deploying the methodology (we believe it is the first paper to explore how scenario planning is used by scientific organizations); and it also contributes to understanding how the construct of post-normal science is enacted in practice. It does so by including in this practice a longer time horizon with which an extended peer community can assess scientific value.

INTRODUCTION

Science has been a cornerstone of Western civilisation since the Enlightenment, if not before. But - particularly with the end of the cold war- the roles of science in society are now in question (Richter, 2002) and according to some scholars, science may itself be facing existential crises, as was for instance explored in the seminar on this topic held in the Institute for Science, Innovation, and Society of the University of Oxford in 2018 (Insis, 2018).

The crises science is undergoing, if one agrees that they exist, may reflect the challenges science faces as it enters what was first called ‘the post-normal age’ in a highly cited and influential paper published by Funtowicz and Ravetz in 1993. Indeed, as Gauthier and Mercuri-Chapuis (2018) established, theirs is the most cited paper in the Web of Science corpus relating to anticipation.

Funtowicz and Ravetz brought forth the question of what future shape might science take when the decisions it informs entail considerable stakes, decision windows are short, values misaligned, and the factuality of facts is disputed. They proposed that a broader set of stakeholders would need to be involved in reviewing scientific claims.

¹ The authors wrote this in their personal capacities, not in the name of their respective organisations

It is worth noting that scenario planning researchers have used the Funtowicz and Ravetz post-normal science construct to inform how scenario planning methods might themselves be required to evolve (Wilkinson and Eidinow, 2008).

In this paper, we assess how ‘intuitive logics’ (Bradfield et al, 2005) scenario planning has been used in organisations whose core purpose is to apply, advance, serve and regulate science on behalf of society. We do so by reviewing how scenario planning interventions were undertaken in three case studies - in the International Atomic Energy Agency, the Royal Society of Chemistry, and in the European Patent Office – and then use post-normal science to help make sense of why these three scientific settings determined to employ scenario planning. While the definition of scenario planning has remained elusive (Harries, 2003; Chermack, 2005; Wilkinson, 2009; Phadnis et. al, 2014; Spaniol and Rowland, 2019) all three cases utilised methodologies which adhere to the ‘Oxford Scenario Planning Approach’ (Ramirez and Wilkinson, 2016).

We explore this through reflection on practice utilising abduction. The three cases are all of organisations whose work is centred on the natural sciences for the benefit of society. The three cases are a convenience sample which became available to the first author through work which three of his students undertook, in two of the cases with his advice. The two other co-authors have been in one case, and in the other case still is, a senior professional in two of these organisations. This characteristic of our sample has considerable advantages in terms of how much information could be gathered from organisations for which confidentiality is essential: “At a fundamental level, qualitative research has as its basis trust and confidentiality” (Pratt et al, 2019: 14).

Our paper is organised as follows. We first explain our methodology. Then we describe and then compare the three interventions to assess how science and scenario planning are engaging each other. We then draw findings from the comparisons; we analyse these and offer concluding comments.

METHODOLOGY

This research is a reflection on practice, where “The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation” (Schon, 1983, p. 68). Or as Finlay (2008) put it, “reflective practice is understood as the process of learning through and from experience towards gaining new insights” (p. 1). This form of research is well accepted in scenario planning at least since Wack (1985) first published his highly cited Harvard Business Review papers. Like Wack, we here use reflection on action, as opposed to reflection in action, a distinction which was first proposed by Schon (1983).

The form reflection on action which we used and report in this paper is abductive. As Bamberger suggested, “Abductive reasoning and empirical exploration studies offer ‘first suggestions’ of

plausible links and explanations grounded on rigorous observations, rather than confirmations of theory-grounded hypotheses” (2019: 103). Furthermore, he argued, the plausible ‘first suggestions’ which abductive reasoning offers are “about phenomena and their explanations on the basis of observations from one’s data (Heckman & Singer, 2017; Peirce, 1883).... “, or, “...as noted by King et al. (2019: 12), “abduction provides nothing more than a means of ‘guessing’, and that the only truth claim that can be made is that a proposed supposition is a plausible one. To know anything further, this supposition must be “subject to further test” (Schurz, 2008).” (Bamberger, *ibid*, 104).

As a result, our findings are tentative and contingent. The extent to which they might be generalisable remains to be established. What we have strived to make sense of, and provide a plausible a scholarly explanation for, is why scenario planning was employed in three distinct -but comparable - science-centred organisations. The surprise is that they would use a method which offers no factual evidence (as it works from and with plausible futures in which fact have not yet come to pass – c.f. Ramirez & Wilkinson, 2016) when all of their work is based on analysing factual evidence. More on this surprise is found below.

This methodology does not require us to contrast our findings with extant views on scenario planning: “unlike deductive reasoning which can be evaluated on the basis of the logical connections between past results and extant theory on the one hand, and a priori predictions on the other (Hollenbeck & Wright, 2017), it is impossible to assess abductive reasoning on the basis of its consistency with past results and extant theory” (Bamberger, 2019: 103). Instead, our findings need to be considered in terms of plausibility and, should they pass this test, can be tested empirically by scholars in the future. Bamberger is the current (2019) editor of the Academy of Management Discoveries journal. There, to enhance the scientific rigour of practices such as abduction, he says that the journal “has, since its founding, pursued **reproducibility** (“the ability of other researchers to obtain the same results when they reanalyze the same data” [Kepes, Bennett, & McDaniel, 2014: 456]), largely by setting a high bar for methodological transparency and rigor. It has also striven for **replicability** (the ability to obtain the same pattern of findings in a separate sample drawn from the same [and/or different] population using the same [and/or different] procedures; Aguinis & Solarino, 2019) by encouraging authors to make every effort to demonstrate that their findings are not the result of some sample- or method-based artifact, and even occasionally requesting that authors of studies grounded on abduction consider self-replicating their work” (2019: 103). We have thus strived to be as transparent as possible in describing our cases and on how we produced our findings so that other researchers looking at the three organisations we have reflected on might be able to reproduce these findings, as well as helping scholars considering other science-centred organisations to assess the replicability of our findings. Yet, as Bamberger cautioned, “although internal replication is an almost inherent element of experimental research ... it may be less feasible for researchers exploring ... findings ... generated from longitudinal data collected over several months or years” (2019: 105) which is indeed the nature of our cases, covering longitudinal data over several years of scenario planning and use .

Abductive reasoning is a relevant methodological choice to assess a surprising situation as “what pragmatist scientist-philosopher Charles S. Peirce called abduction: a central concept in his theory of logic and inference that denotes the creative production of hypotheses based on surprising evidence” (Timmermans and Tavory, 2012:168). The surprising situation or puzzle (Schon, 1983) which we attempted to understand is that organisations whose work is centred on positivist science – which base their own scientific work on evidence and fact, all of which are in the past; might use a method which explores possible futures where fact is not yet actual and evidence is non-existent. A similar question was explored by Medjad and Ramirez (2007) concerning why lawyers -who like scientists, also look for evidence in the past- would utilise scenario planning.

Timmermans and Tavory suggested that steps in abductive reflection involve (a) revisiting the phenomenon which one has experienced; (b) defamiliarizing oneself with it; and (c) what they called ‘alternative casing’ (2012: 175-78), which corresponds to what Ramirez & Wilkinson (2016) termed ‘reframing’. We have followed their advice for each of the cases.

Thus, to (a) revisit the experiences of the cases we lived through or wrote about earlier, we went back to look at what we lived through. Author number two was a senior executive in the EPO -an organisation which he left two years ago- and he went back through his notes and publicly available documents to write the first version of the case study that we describe in our paper. Author number three is a senior professional in the IAEA and, like author number two, revisited what she and her colleagues did to write the first version of the case in this paper. Author number one was involved in the scenario engagements of these two organisations (in the EPO, August 2004- to June 2007, with the scenario set released in July 2007; with the IAEA, January to April 2016) and reviewed these drafts based on his own recollections. The third case, the Royal Society of Chemistry, has been analysed by author one and other colleagues in a prior paper (Ramirez et al, 2017) and that analysis -also reflection on action when originally published- is reproduced here with the additional verification which author one undertook with the senior professional who conducted the scenario planning there that this now (2019) two year old account is still correct.

To (b) defamiliarise ourselves with our own experiences, we followed what Goody (1977) noted more broadly: that as Timmermans and Tavory put it “we actually think differently in textual than in atextual modes of engagement. The inscribed text both problematizes and crystallizes things that we would gloss over in atextual accounts. Certain similarities, logical fallacies, lists, and detailed comparisons become possible as technologies of the intellect. Rather than lamenting the inscription of experience as a loss of immediacy, abductive analysis creates a different—defamiliarized—object that provides us with opportunities and modes of thought that we gloss over in our immediate experience... Defamiliarization thus augments the researcher’s ability to revisit the data in ways that increase the fecundity of abductive reasoning. Whereas revisits are analytically dependent on shifting relevancies over time, the artificiality of inscription allows the researcher to create semantic distance from the taken for granted” (2012: 177). Writing up the cases, having them peer reviewed by co-authors and rewriting them accordingly; then comparing them, and revising them with the

reviewers' comments has helped us to both de-familiarise ourselves with the original experiences and to re-view these in light of the learning which this research has produced for us.

Finally, to be able to do (c) alternative casing or framing, Timmermans and Tavory propose that "The switch from induction to abduction ... requires a gestalt switch in which the theoretical background is foregrounded as a way to set up empirical puzzles" (2012: 177). We did this by fore-grounding the post-normal science theoretical construct. In doing so realised that scenario planning enriches the broader peer review which that theory suggests science requires in post-normal times. It does this enriching by making the differences offered by that broader peer review more effective by adding an explicit temporal difference into the assessment. Scenario planning contributes to this enhanced effectiveness of review by situating the views in conceptually plausible future positions. As scenario planners and scholars have established (Wack, 1985, van der Heijden, 2005, Ramirez & Wilkinson, 2016) perspectives from the future helpfully contrast with accepted present views to provide insight, re-perception, and usable information. When exactly the novelty scenario planning produces for its intended users arises a given engagement remains unclear, though recent research (Mukherjee et al 2019; Frith and Tapinos, 2020) attempts to clarify this matter. This mystery is also one for scholars who study abductive reasoning: "Pierce treated scientific work as an ongoing act wherein discovery and justification are inseparable moments" (Timmermans and Tavory, 2012:170). Timmermans and Tavory show that from the very beginning, abduction has been concerned with making this novelty come forth: "Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new ideas; for induction does nothing but determine a value, and deduction merely involves the necessary consequences of a pure hypothesis" (Peirce 1934:171)..... "Abduction seeks a theory. Induction seeks for facts" (Peirce 1958:217-18)" (both citations in Timmermans and Tavory, *ibid.*)

Our cases are not statistically representative of any possible set of science-centred organisations; instead they are a convenience sample with which the first author has become familiar. This 'ready at hand' or 'handy' convenience sample characteristic itself makes abductive reasoning a pertinent form of analysis of reflection on action: "Abduction should be understood as a continuous process of conjecturing about the world that is shaped by the solutions a researcher has "ready-to-hand" (Heidegger [1927] 1996).... a way to conceive of abduction as socially located, positional knowledge that can be deepened and marshalled for theory construction..... wherein much is made of the fact that the researcher is part of the world of the people studied. This being-in-the-world, however, is far from being a guarantor for truth but is a core issue to be grappled with, inevitably leading to partial, historically situated insights, and provoking questions of scientific authority and representation" (Timmermans and Tavory, 2012:172).

Given these characteristics of abductive reasoning, the findings from our research, while they are intended as plausible and useful, are thus partial and tentative and will need to be tested empirically by scholars in the future.

Still, “The theories developed in abductive analysis denote an attempt to generalize causal links and descriptions of the world out of particular empirical instances (see also Abend 2008:177–79; Gross 2009). Such theories depend on the fit with observations and their plausibility in light of alternative theoretical accounts.... Abductive analysis specifically aims at generating novel theoretical insights that reframe empirical findings in contrast to existing theories”. (Timmermans and Tavory, 2012:174).

SCENARIO PLANNING IN THE IAEA DEPARTMENT OF SAFEGUARDS

The International Atomic Energy Agency (IAEA) is the world’s central intergovernmental forum for scientific and technical co-operation in the nuclear field. It was created in 1957 in response to the deep fears and expectations generated by the discoveries and diverse uses of nuclear technology. Set up as the world’s “Atoms for Peace” organization within the United Nations family, it works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The objectives of the IAEA’s dual mission – to promote and control the Atom – are defined in Article II of the IAEA Statute². The latter mission is performed through so-called ‘safeguards’, a set of technical measures through which the IAEA independently verifies that States are abiding by their international commitments³ to use nuclear material and technology only for peaceful purposes, thereby supporting global efforts to stop the spread of nuclear weapons. The Department of Safeguards carries out the IAEA’s duties and responsibilities as the world’s nuclear inspectorate.⁴

In 2018, the IAEA safeguarded nuclear material amounting to the equivalent for the potential production of 212,000 nuclear explosive devices.⁵ IAEA inspectors spent approximately 13,000 calendar days in the field carrying out some 2,200 inspections in over 1,300 nuclear facilities worldwide. The Department of Safeguards relies heavily on a wide set of scientific methods and technologies in carrying out its work; in collecting, processing and analysing States’ declarations and other safeguards relevant information (e.g. satellite imagery and other open source information); in carrying its inspections in the field; in applying surveillance and monitoring systems and seals; and in taking and analysing nuclear material and environmental samples taken in the field.

² “The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.”

³ States accept these measures through the conclusion of safeguards agreements. 182 States have concluded safeguards agreements with the IAEA, including 174 States that are party to the 1968 Nuclear Non-Proliferation Treaty (NPT). Under the Treaty’s Article 3, each non-nuclear weapon State is required to conclude a safeguards agreement with the IAEA.

⁴ This paragraph is adapted from the IAEA website, as accessed on 20 November 2018: <https://www.iaea.org/about/overview> and <https://www.iaea.org/about/overview/history>.

⁵ So-called 210,000 ‘significant quantities’. One significant quantity is the amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be ruled out.

Throughout its more than 60-year history, the IAEA has adjusted to changing circumstances. Some of the ‘TUNA’⁶ like past developments have included the conclusion in 1968 of the Nuclear Non-Proliferation Treaty (NPT), which made the IAEA into the world nuclear inspectorate of the magnitude it is today. Other challenges along the way include the discovery of Iraq’s clandestine nuclear weapons programme and the DPRK’s non-compliance with its safeguards agreement in the early 1990s. Such events highlighted the limitations and changed the extent of stakeholder expectations of the then IAEA safeguards system. They also expanded the organization’s legal rights, providing new tools⁷ to better detect undeclared nuclear material and activities. Libya’s admission in 2003 that it had engaged in nuclear weapons related research, using technologies purchased through covert supply networks, manifested the impacts of globalization on the work of safeguarding. More recently, the IAEA significantly expanded its verification activities in Iran following the conclusion of the Joint Comprehensive Plan of Action (JCPOA) in 2015 between Iran and the E3/EU+3; some fifteen years after information first came to light about Iran’s undeclared nuclear material and activities. Such TUNA developments have thus had significant impacts on the IAEA.

The IAEA Department of Safeguards conducts strategic planning to help ensure that safeguards continue to be implemented effectively and efficiently into the future. Monitoring and analysing the operating environment have long underpinned the Department’s strategy work. However, the Department in 2016 introduced scenario planning into its planning toolkit. At the time the Department was in the process of reviewing and updating its strategic plan.

Up until then, the Department had conducted an external environment analysis regularly. It, for example, considered developments in the nuclear industry and stakeholder views expressed in its policy-making organs (e.g. IAEA Board of Governors), thereby focussing more on its immediate operating environment – or what the Oxford Scenario Planning Approach considers the ‘transactional’ environment. Also, while the analysis did include some projections (e.g. on nuclear power generation and numbers of nuclear facilities) that could be used to estimate future workloads, it was more focussed on the present rather than on the future. An example which is externally available is the IAEA’s corporate level strategy for 2012-2017⁸, which was focused on the present or near-term future and did not consider any potential significant deviations from what was then the present and expected a more linear future to unfold. The analysis also didn’t take into account more significant, potential departures from the expected trajectory. The decision to try scenario planning as a complement to existing analyses was driven by the Department’s strategic planning team, located in the planning division, and recommended by an external advisory group⁹. It was motivated by the Department’s desire to be better prepared for the future and to address the perceived need to consider a wider set of drivers of change given the increasing overall

⁶ Turbulent, unexpected, novel and ambiguous (TUNA) – Ramirez and Wilkinson, 2016.

⁷ The so-called ‘additional protocol’, which provided broader information about, and inspector access to, all aspects of a State’s nuclear fuel cycle.

⁸ https://www.iaea.org/sites/default/files/mts2012_2017.pdf.

⁹ The Standing Advisory Group on Safeguards Implementation (SAGSI) which advises the IAEA’s Director General.

unpredictability about the future. There was also a desire to discover how scenario planning might enhance strategic thinking and support decision-making in the Department.

Following scenario planning education undertaken by one of the authors at Oxford, the Department invited experts to provide in-house education in Vienna, which included another co-author. This education was provided to some fifteen mid-level managers in the Department's cross-divisional and multidisciplinary strategic planning team. The team then embarked on the development of scenarios during a two-day workshop, using the inductive method (van der Heijden, 2005). This was preceded by advance research to make the workshop as productive as possible. After several scenario development iterations in smaller sub-groups, the participants then looked for common themes among the various draft scenarios. They produced a set of 4 contrasting scenarios with drivers considered as impactful on the Department's work.

The scenarios were further researched and refined over the course of a few weeks, before being presented to the Department's senior management team. The presentation was preceded by a briefing and an immersive exercise for the senior management team, which provided the necessary background on scenario planning. The many commonalities in the themes explored by both the departmental team and the senior management team helped to validate the proposed scenarios.

Eighteen months later, the Department's strategic planning team, complemented by a set of staff members new to the scenarios, revisited the scenarios as part of the regular review and update of the operating environment. The addition of new people was useful for bringing new perspectives and questioning previous assumptions. The initial set of scenarios was critiqued for plausibility, relevance and ability to challenge. In doing so, the team evaluated whether the signals identified earlier had strengthened. Some scenarios were changed more substantively, and others less so. One change was the renaming of all the scenarios with more descriptive names, to help recall their various dimensions.¹⁰

Perhaps unsurprisingly for an organisation with staff of scientific and technological backgrounds, discussions about technologies featured prominently in the generation of the scenarios. So much so that one of the scenarios was dedicated to envisaging what the nuclear industry in general - and facilities in particular - might look like by 2030. The implications resulting from, for example, transportable reactors to the Agency's verification work were analysed in order to inform strategy – sparking thinking of the kinds of safeguards approaches and equipment that will be needed. Another two scenarios related to technology also. In one scenario, the Department explored a world fundamentally changed by non-nuclear technologies such as artificial intelligence, sensors and robotics; one of digital dependency and automation where keeping up with technologies is not only a question of organizational effectiveness and efficiency but also of its survival. This scenario raised questions also about the implications to the Department's workforce, in terms of the kinds of competencies required in the future. Another scenario explored the darker side of technologies:

¹⁰ It was observed that the previous, shorter and more caricature-like names, although good for memorization purposes were too one-dimensional to accurately reflect the richness and complexity of the scenarios.

when technologies such as additive manufacturing lower proliferation barriers and cyber threats endanger information assets, challenging the organization to stay ahead of the game.

The scenarios were used to inform the Department's review and updating of its strategic plan - a publicly available reports from the ETW 2017 and a summary of their strategic plan ¹¹ the Department's R&D Plan, contain objectives that were informed by the scenarios, including for example, 'Leverage and establish partnerships' which was directly informed by one of the scenarios. The Department also used the scenarios to affirm the challenges, opportunities, and risks identified through other processes (such as the SWOT analysis¹²)— and to expose blind spots in the Department's analyses. Later, they were used to evaluate the effectiveness of the strategies to address them.

Reflecting on the use of scenario planning in the IAEA Department of Safeguards, there are a few observations that come to mind which may resonate for professionals in other science and technology-based organizations. First, it is important to properly introduce scenario planning from the start, to set the right expectations and avoid misconceptions. For example, clarifying that staff are not being asked to evaluate the likelihood of scenarios (i.e. 'probable' scenarios) but rather to envisage *plausible* scenarios helps to avoid debates about probabilities. It was also helpful to introduce scenario planning with the help of experienced and internationally recognized experts. In an organization with many staff with scientific backgrounds like the IAEA, there is often a search for 'evidence'. This was compounded by the fact that the very mission of the Department is one of *verification* c.f. IAEA, 2017. Here, the identification of 'early signs' played an important role in gaining acceptance: trends were seen as more plausible where there were already identified signs that the world was heading in that direction. Following the generation of first set of scenarios, some of the participants began to spontaneously track developments and send further evidence in the form of, for example, articles on technology developments. It also helped to accept scenarios when they were seen not as competing alternatives but as several possible co-existing futures: in the Department's case, it was recognized that elements from all four scenarios could well occur simultaneously, given the complexity of the operating environments across the globe.

Given the diverse professional backgrounds which IAEA staff hold, it was found also important to involve staff from different parts of the organization, which had the added advantage of allowing to leverage staff expertise to the fullest. Furthermore, involving both the mid-management and senior management levels helped not only to enhance the quality of the scenarios, but also their being taken up and used.

Finally, to ensure the scenarios' credibility, it was important to recognize the natural limitations in the participants' expertise; and with this recognition, to gain recognition for the need to research topics further, often with the help of external resources. This may be especially true to organizations with people with scientific and technical backgrounds that may be quicker to recognize the limitations of their knowledge outside to their own expertise. This led to one important and tangible

¹¹ <https://www.iaea.org/sites/default/files/18/09/emerging-technologies-130217.pdf> and page 9 of <https://www.iaea.org/sites/default/files/18/09/sg-str-385-research-and-development-plan.pdf>

¹² Strengths, weaknesses, opportunities and threats (SWOT).

outcome of the scenarios experience being the decision to strengthen the Department's awareness of other (i.e. non-nuclear) emerging technologies: the Department in 2017 explored these in a workshop with the help of external experts. The outcomes informed the development of the Department's next Research & Development (R&D) Plan, which identifies those needs where it is reliant on external support (e.g. tools, techniques, methodologies and expertise).¹³ More recently, some of the themes identified in the scenarios and the emerging technologies workshop were further explored with a wider set of some 800 stakeholders (mostly with scientific and technical background) at the 2018 international Safeguards Symposium, under the theme of 'Building Future Safeguards Capabilities'.¹⁴

In conclusion, although the Department's experience is still young, scenario planning has become an integral part of the Department's set of strategic planning methodologies. It has been found to broaden environment awareness and elevate strategic thinking, to help to question existing assumptions, and to deepen external environment and risk analyses.

Including scenario planning into the planning methodologies has also helped the Department to move to a more 'living' strategic plan which requires more constant monitoring of the operating environment and analysis of the signals it sends. As such, scenario planning also has helped increase organizational agility, with better awareness of, and preparedness for, a greater variety of futures.

SCENARIO PLANNING AT THE ROYAL SOCIETY OF CHEMISTRY¹⁵

The Royal Society of Chemistry seeks to advance excellence in the chemical sciences for the benefit of science and humanity. It was founded in the 1840s, when 77 scientists, who included doctors, academics, manufacturers, and entrepreneurs, founded the Chemical Society of London. The Society currently has some 60,000 members in all continents and has gained a reputation as an influential champion for the chemical sciences.

The multiple changes of how people live have always affected the practice of chemistry, the roles of chemists, and even the very nature of both chemistry and science. A question which arose for the Society's leadership is how this might be shaped in the future.

While chemistry is a mature discipline which has contributed to fundamental understanding of what happens at the atomic and molecular levels, it is also reinventing itself all the time. It relates to engineering, physics, biology, astronomy, material science and many other scientific disciplines, as well as fields such as ethics and climate change. In addition to being an academic discipline, like engineering or medicine; chemistry is also a profession, with chemists seeking to play a key role in

¹³ <https://www.iaea.org/sites/default/files/18/09/emerging-technologies-130217.pdf> and <https://www.iaea.org/sites/default/files/18/09/sg-str-385-research-and-development-plan.pdf>.

¹⁴ <https://www.iaea.org/events/symposium-on-international-safeguards-2018>.

¹⁵ This section of the paper is derived from the relevant sections of an earlier article: *Using Scenario Planning to Reshape Strategy*, Ramirez et al, *MIT Sloan Management Review*, Summer of 2017 issue, with permission from MIT-Sloan-Management Review

solving practical problems such as curing disease; developing sustainable energy, food, and water; and creating new industries (Matlin et al, 2015).

Chemistry has also been blamed by many for having created substances which cause pollution and disease (Carlsson, 1962; Robin, 2008), and so stringent codes of scientific as well as professional conduct have arisen over the years to better police the values which -presumably- the majority of chemists aspire for their profession.

As chemistry faces new opportunities and obligations, a fundamental question which the Royal Society of Chemistry (RSC henceforth) set out to explore was: “How should people think about the future of chemistry?” (c.f. Whitesides, 2015). This was part of an effort launched in December 2014 by the RSC as a long-range planning initiative with a broad set of goals. Although the initiative initially did not refer to scenario planning per se, its aim was to identify possible future directions for the chemical sciences and to anticipate, plan, and prepare for how the field might unfold over the next 10 to 15 years. As we shall see, the RSC then decided to use scenario planning to articulate these possibilities in a usable manner.

The RSC began by identifying some of the big questions its leadership wanted to consider: How might the identity of chemistry change? Could chemistry be facing a future in which academic chemistry departments disappear altogether? If public funding is not available to support the type of blue-skies research that has traditionally produced the next major advances, how will future research be funded? And how will increasingly sophisticated technology and computational techniques change the way new hypotheses are analysed and tested?

The RSC convened a one-day workshop for the leadership team and selected senior managers to consider a wide range of factors. The workshop helped focus senior staff members across the whole reach of the organization on the usefulness of taking a broad look at how the field was changing. It was agreed that doing so would help to set the stage for identifying and then defining the new roles which the RSC could play in the future.

They agreed that scenario planning was a methodology which would help them to marshal the research that had been done and to help them prepare the field for different possible futures. The objective of the scenario planning process was to understand how the chemical sciences might evolve over the next 10 to 20 years, and how the changes might impact industry, academia, and society at large.

What followed was the development of a multiphase scenario planning program.

In phase one, which ran for three months, approximately 50 stakeholders from industry, government and academia who had been selected by the RSC leadership team, were interviewed by phone to identify possible trends.

This was followed by a second phase where individual interviews were undertaken with some of the stakeholders to better appreciate controversial viewpoints or, in some cases, to secure buy-in from key chemical industry leaders.

During this second stage several themes emerged. Some directly concerned the chemical sciences (for example, new opportunities for funding research). Others raised questions about how technology might influence the chemical industry; and about how changes on intellectual property, the market, and social factors might reshape chemistry - as a scientific field, and as a profession, and as business practices.

The RSC in a third stage then ran three one-day scenario-planning workshops (two in London and one in Boston) attended by about 10 people each. These facilitated workshops as a vehicle to assess the themes from phase two, to appreciate how they might in the future relate to each other, and to identify weak signals which might be precursors of things to come that the RSC ought to attend to. This third stage sought to convene novel conversations about the future to invite executives, academics, and policy-makers to be more courageous in their query of the status quo and ongoing trends, and to make decisions more proactively and -perhaps- considering implications of these decisions over longer time horizons.

Four scenarios were developed -

- One considered benefits chemistry offers and its role in helping to address global challenges such as climate change, water shortages, natural resources scarcity, and providing health care for an aging population.
- A second one assessed how chemistry might be changed – how it is done and organized. It explored the chemical sciences becoming much more automated and decentralized.
- With a third scenario the RSC imagined the field of chemistry becoming broken up into subdisciplines. It was considered that this might negatively impact the number of chemists.
- With the fourth scenario the RSC evaluated the impacts reduced public funding would have on the chemical sciences.

With these scenarios the RSC informed its long-term strategy and sought to nudge leaders in the chemical sciences to move beyond conventional thinking and to improve their planning. At the time of this writing (early 2019), the RSC's original long-range planning team continues to play a role in encouraging the chemical community to reflect on opportunities and challenges with the help of this original set.

The findings from the scenario planning process were first issued in a report (RSC, 2016). It at that time sought to broaden the engagement with RSC communities. The organization initiated then new activities based on the challenges identified in the scenarios, including launching new programs to advance the future of chemistry education and scholarly communication consistent with developments in open-access publishing and the trends in open science; bringing the RSC "futures thinking" conversation to a wider audience (including the organization's general assembly and meetings with international partners around the world); and preparing for the different possible

futures through internal strategic conversations with senior management and the RSC's external governing body.

The RSC's new strategy, which the governing board approved in July 2017, was tested against the opportunities and challenges identified by the scenario planning work. The next priority was to amplify the voice of the chemistry community. This involved the RSC management sharing success stories from the chemical sciences community not only with other companies but also with governments, funders of research, and society at large. In addition, the RSC set out to better listen to the broader community, to better understand community needs, and to learn how to respond more proactively.

SCENARIO PLANNING IN THE EUROPEAN PATENT OFFICE

The European Patent Organisation is a self-financing inter-governmental organisation independently set up by a diplomatic conference of Member States in 1973 to establish a uniform patent system in Europe, which was done under the European Patent Convention. Its mission is to “support innovation, competitiveness and economic growth across Europe”. The Organisation's operational arm, the European Patent Office (EPO), delivers a single unified procedure for thirty-eight Member States.

In addition to its European duties, the EPO is the world's largest International Search Authority under the UN-based Patent Co-operation Treaty. It also executes national “prior art patent searches” for France, Italy and the Benelux countries. After a patent is delivered by the EPO, it becomes a bundle of national patents in up to 44 States. With the introduction of the Unitary Patent¹⁶, patent owners can opt to replace this bundle system by a single patent for 25 European Union States.

The EPO works in three official languages (English, French and German) and has its headquarters in Munich. Its approximately five thousand patent examination staff hold a university-based scientific degree. The remaining two thousand staff members in management, IT, legal and support functions will also, typically, have some form of university education. The main operational counterparts they collaborate with are some 12,000 qualified European Patent Attorneys working in either industry or private practice (see EPI)¹⁷.

¹⁶ European Patent with Unitary Effect. https://en.wikipedia.org/wiki/Unitary_patent.

¹⁷ At the operational level, the IP industry (attorneys and IP Offices alike) is organised by technical field with a group of experts in that technology interacting with their procedural counterparts. In the scientific structures of the EPO, and most other IP Offices, staff and incoming workload are allocated to a unit based on an objective definition of the industrial sector to which it belongs, using internationally accepted standards. In the non-scientific structures of the EPO, staff are organized by procedure or legal framework. Rules, procedures and practices seek to minimise discretion, increase consistency and thereby improve the legal validity of the granted right.

The EPO's engagement with scenario thinking started in the late 1990's. At the time, and this has developed further over the following decades, the world of intellectual property was being buffeted by a number of powerful external forces. We review these succinctly in the following paragraphs.

Economically, ever since the early 1980's, the financial importance of intellectual property has been on a strong upwards spiral. This has been driven by globalisation and the emergence of the knowledge economy. As a result, stock markets across the world saw a strong growth in the economic value of intangible assets in general, and intellectual property in particular. As an illustrative example, in nominal terms, international (i.e. not domestic) licensing and royalty revenue grew from USD 3.5 billion in 1970 to USD 700 billion in 2015 (Neubig and Wunsch-Vincent, 2017).

Globalisation thus drove the EPO's workload, for patents filed in one country increasingly became re-filed in many others. The resultant strong growth, interrupted only temporarily by the financial crisis in 2008, clogged up the operations of the patent system. At the same time China and South Korea became global powers in patenting, so the resultant interdependency of the global patent system reinforced the politicisation of patents and brought forth a requirement for increased levels of co-operation between the major players.

In the world that had become so dependent on innovation and science, the in-house R&D model made way for different forms of "open innovation". Intellectual property rights (IPRs) have come to be increasingly used to cement strategic and commercial relationships. The growing gap between market to book ratios in company valuations drove many in the finance world to monetarize IP.

In technical terms, the volume of prior art assessment requests exploded with the advent of publication of IP rights on the internet. Innovation has become increasingly positioned at the boundaries between industries, which makes specialist IP searches more difficult, as interdisciplinary teams must be built and made to work together effectively. Finally, changes in the very nature of innovation and science led to more fundamental challenges on the very nature of patenting. An example is determining whether patent protection should be available for "life" in the form of gene sequencing. Another is defining which forms of IP, if any, should apply to software and business methods.

For the EPO, the growing patent application backlogs became a constant theme for EPO's senior management meetings. The backlogs also took on the role of becoming a permanent backdrop to other, more contextual, changes. The simmering tension between those who advocated centralisation (EPO as a centre of competence, more Europe) and those who supported decentralisation (local expertise required, less Europe and more country-by-country) as the 'best' approach to carry out patenting framed such emerging and increasingly salient issues in incompatible ways.

Unsurprisingly perhaps, as the backlog pressure mounted challenges to operational efficacy, the application of International Accounting Standards revealed flaws in the cash-in/cash-out approach that dominated the EPO's budgetary model. This led to reforms of the EPO's pension and social security schemes, which were straining the self-financing model of the EPO.

It is against this backdrop that the EPO got involved in scenario planning. Initial contact in the late 1990's with Shell and other scenario thinking organizations led to the co-sponsorship, between Shell, EDF, EPO and the UK Health and Safety Board, of the Risk2020 scenarios (Wilkinson et. al., 2003). The results were widely shared inside the EPO and the risk thinking which emanated from that initiative became integrated into EPO strategy. That strategic integration was relatively seamless as scientists and engineers naturally tend to think in terms of risk management. Furthermore, the quality-based, legal process to arrive at a decision to grant a patent can be easily described from a risk management perspective.

But one key lesson from the Risk2020 scenarios, namely the trade-offs between expert-led decision making and wider participation, was largely ignored. This came to matter as the patent system itself is a complex mix of legal, scientific and regulatory frameworks. EPO staff and patent attorneys are specialists and experts in each of these areas; but especially in the late 1990's and early 2000's, any involvement of a wider group of stakeholders was deemed a waste of time. Although it was not realized so much at the time, this view was about to change when the EPO decided to launch its own scenario project in 2004 looking into the future of IP systems.

The original thinking behind the 2004 decision was to seek to develop a broader look at how the different contextual drivers, described above, might come together. The purpose of doing this was to better formulate strategy. Initially, it was thought that this could be achieved by adapting the Risk2020 scenarios, but this view was quickly dismissed, and it was replaced by a dedicated IP scenario planning project that lasted until 2007.

One of the first steps that was undertaken was to interview a broad group of experts with very different views on IP. Although the target initially was to interview no more than 30, in the end 120 people from across the world were interviewed and a collection of some 80 key interviews was published¹⁸. This was a pivotally important publication. It demonstrated to stakeholders outside the organisation and to key staff in it that EPO was working in a hugely unsettled environment. Indeed, no-one interviewed said "leave it alone" and all participants welcomed the EPO's initiative. It completely broke down the "we are the experts" barriers that had been erected by a lot of EPO staff, many in the attorney profession, and numerous patent experts in the EPO's administrative bodies.

As a result, when the final set of four scenarios (see figure 1) were presented in April 2007 in a public event attended by hundreds of IP experts from around the globe to Chancellor Merkel (who then held the presidency of the European Union and was key note speaker in that event), the previous characteristics of the organisation which resembled an ivory tower revelling in scientific isolation was – at least for a number of years, dismantled. The scenario planning process itself, the published

¹⁸ *"Interviews for the Future"*. Munich, EPO, 2007 (652 pages). A PDF version can be found online at <https://people.ffii.org/~zoobab/bh.udev.org/filez/swpat/EPOInterviews/EPO-Interviews%20for%20the%20Future.pdf>

interviews and the different plausible futures to which it gave rise, at least initially led to a form of strategic renewal inside the patent system.

Figure one here

Some initiatives and decisions made during the period are still in place today. Internationally, an institutional collaboration between the US, Japanese, Chinese, South Korean and European patent offices (IP5) was established. So too was a patent classification scheme for green technology. In Europe, the so-called London Protocol¹⁹, and the EU Unitary Patent and Centralisation Protocol finally got the necessary political support to be implemented. And the EPO's Inventor of the Year celebrating scientific innovation was launched.

With the benefit of hindsight, and in the light of these enduring successes, the central challenge was to get the scientific stakeholders to be willing and able to better see the wider context. The geopolitically dominated Scenario "Whose Game" had the biggest impact on the organisation followed by the "Trees of Knowledge".

"Whose Game" showed the dangers inherent in a fragmented global patent system and how such fragmentation could feed into global trade conflicts. At the time China was only starting to emerge as a major player in the global IP system. This scenario encouraged the EPO which, together with the German Patent and Trademark Office, was already supporting the Chinese Patent Office operationally, to integrate them more fully into international co-operation bodies.

"Trees of knowledge" illustrated the importance of the role of the global patent system in disseminating knowledge. Hitherto, the EPO had focused more on the mechanics of publishing patent applications and granted patents. This scenario encouraged many scientific staff to find ways to share insight and knowledge that they had acquired in the course of their work. One of the first examples of this thinking that came directly from the scenario exercise was the co-creation with the IPCC of a special patent classification scheme for "green patents" that could feed the climate change debate. This thinking has continued to this day with the most recent example being a publication about autonomous vehicles.

But these notable exceptions aside, the rational scientific thinking inherent in the training and professional identities of both EPO staff and attorneys led to the Market Rules Scenario becoming the 'preferred' one. Comments about it such as "This is the nice world"; "I understand this" and "We know how to manage this" were common refrains. The serious downsides of this Scenario, an IP system that is so successful it collapses under its own weight, were somehow put to one side and ignored.

¹⁹ Agreement on the application of Article 65 of the Convention on the grant of European Patents (a.k.a. London Protocol). [https://en.wikipedia.org/wiki/London_Agreement_\(2000\)](https://en.wikipedia.org/wiki/London_Agreement_(2000)).

And whilst the scenarios of Market Rules, Trees of Knowledge and Whose Game were easily understood and accepted as plausible by the main scientific communities (EPO staff and attorneys), the same could not be said of the Blue Skies scenario. This scenario was frequently misunderstood because it relied on the concept of systemic risk. It presented a world in which the sheer scale of interdependency of technologies and systems became an unpredictable challenge. For most patent specialists, their scientific background meant that as soon as a specific systemic risk was identified in the Scenario, they then focused on the illustrative example rather than on the underlying uncertain factors coming together which had led to the example existing in the first place. Strangely enough, they focused more on the symptom than on the disease or the public health issues that bring forth the disease.

Over time, the EPO Scenarios ran their course and there was no long-term follow-up inside the institution, although they continue to be used across the world even today. There are various reasons for this. The dominant reason comes from the EPO's senior management where, from around 2005 onwards, it was increasingly obliged to focus on reforming its performance and rewards system, including various social security schemes. From a policy perspective, at least in Europe if not elsewhere, the dominant view on patenting policy was best represented by one minister who simply took the view that lots of money being spent by free thinking people equals a good IP system.

But a deeper reason for the lack of follow-up may also be in play. There is ample evidence of a conflict in the highly scientific patent eco-system between "expert" and "scenario" thinking. For adherents to the "expert" thinking model, the idea that non-scientific stakeholders, including NGOs, judges, and economists should have a real and meaningful say in the running of the patent system in Europe is not embraced. It is easy, particularly if you are a skilled person with a potent mix of legal, procedural and scientific expertise, to dismiss the views of such stakeholders – particularly if their discourse is framed in ways that do not match the "official" language of the profession.

For adherents to the "scenario" thinking model, all stakeholders must have a real and meaningful say in a system that relates benefits to society with private investments in science and innovation. For them the IP system is not an ivory tower built for the benefits of those in the profession. Instead, the IP system is intended to serve a societal purpose – to support innovation, competitiveness and economic growth - and its sustainable legitimacy relies on how it fulfils that purpose having continued broad political acceptance.

COMPARING THE THREE CASES

As a case study data set, these three organizations exhibit many similarities among them. All three organizations have purposes which are fundamentally scientific in nature: to verify with scientific and technical rigor that nuclear material has not been diverted to non-peaceful purposes; to advance chemistry as a field and a profession; and to use science to ascertain the veracity and validity of prior art claim. All three can be considered as not-for-profit institutions whose mandate is to serve some sort of public good –ensuring the peaceful use of nuclear energy in the case for the

IAEA; improving the roles chemists can play to benefit society in the case of the RSC, and providing a good balance between private investment returns and benefits to society concerning invention activities in the case of the EPO. All three include a majority of scientists in their ranks and all have extensive stakeholder networks which are both scientific and non-scientific.

To look at the differences among the three cases, we abductively (Mantere and Ketoviki, 2003) developed the following five-part framework (see figure 2). It has the management leadership team at the center of the scenario planning intervention, as a customer and as the force driving it forward. They are surrounded by four groups with whom they or their scenario planning initiative interacted – in-house scientific and non-scientific staffs and then external scientific and non-scientific stakeholders. We assess similarities and differences for each of these five groups.

Figure 2 here

A. Senior Leadership Team

With the exception of the IAEA²⁰, it was the senior leadership team who propelled scenario planning forward. The teams were all new to scenario planning and thinking when the intervention started. EPO was the first to start engaging with scenario thinking in 2001. As we show in Table 1 below, the reasons for launching scenario planning across the three organizations were similar, as was also the case with measures taken to become reasonably comfortable with both the process and the utilization of the outcomes. The IAEA and EPO had the objective of complementing shortcomings in their existing planning processes. While for the RSC this was not among the initial motives, the resulting scenarios were later used to improve planning. There was a desire in all three organizations to better understand how the broader contextual trends would come together and impact the organization.

Table 1 here

The way the scenario planning was introduced and carried out and the scenario outcomes also exhibit important similarities across the three cases, as is evident in table 2. In every case, the organization went through a considerable learning process. For each the distinction between scenarios as being plausible futures as opposed to being predictions having probabilities was an important one.

The general sense we gain from comparing the three cases is that organizations whose work depends on science (including the economic sciences) are more intuitively orientated towards making predictions or allocating probabilities regarding the future because scientists are educated to look at data and model it, not to imagine possible futures where yesterday's data or their patterns

²⁰ The reference to IAEA refers henceforth to the IAEA Department of Safeguards for the purposes of this paper.

might be irrelevant. And yet, as this is the very anthesis of scenario thinking, having a method that is rigorous but not 'scientific' in that sense appears to be acceptable, not least to support the holding of broader, more complex, more courageous and higher quality strategic conversations (van der Heijden, 2005).

It also appears that the validation of plausibility undertaken by the three institutions through peer review and multiple iterations were more extensive (and in this restricted sense, 'scientific') than might be the case in those non-scientific not-for-profit (or for profit) organizations who only do one iteration of scenario planning (for a critique of that approach, see van der Heijden, 2005).

Table 2 here

B. Internal Scientific Staff

The personnel of all three organizations are dominated by scientific staff. As table 3 shows, they were involved, alongside top managers (many of whom hold PhD degrees in science themselves) in the development of the scenarios; in some of the cases those who were not involved required further explanations. This supports the view that having scientific training is not in itself a detriment to carry out effective scenario planning work to a very high standard (see also the United European Gastroenterology case in Ramirez and Wilkinson, 2016).

Table 3 here

C. Internal Non-Scientific Stakeholders

Each of the three organizations have a minority of nevertheless very important staff members whose education is not in science; or -even if they were educated as scientists- now hold roles which are not centered on science (such as marketing, IT, administration, legal, communication etc.). Given the recruitment policies and missions of all three organizations, most of non-scientific staff will have completed university education – even if they are employed in administrative support functions.

In all three organizations, the majority of non-scientific staff were not directly involved in the scenario development work. At both the IEA and the EPO, management and planning staff were however intensely involved. Furthermore, given the judicial nature of the patent system, the EPO had key legal staff embedded in the scenario team.

In terms of the reaction of non-scientific staff to the scenarios, it was universally positive among those who were exposed. At the EPO, it gave such staff a sense of belonging to the organization as well as providing context and purpose to their function. In the RSC, it helped the organization gain positive recognition for thought leadership.

D. External Scientific Stakeholders

Each of the three organisations has intensive as well as extensive relations with external stakeholders. They each have a scientific mirror reflecting the composition and interests of internal scientific staff; composed of course of scientists. The views of these external scientific stakeholders regarding scenario planning and its outcomes would be typically shared directly with their counterparts inside the three organizations.

Positive feedback would create a re-enforcing loop that augmented the legitimacy and authority of the agency which produced the scenario set. This was an effect that was especially visible in the EPO and RSC cases where the scenarios were exposed to a wide range of external scientific stakeholders. The IAEA did not explicitly share the scenarios outside the organization, although an external advisory body acknowledged the introduction of scenario planning into the planning process.

Negative feedback also existed, notably in the case of the EPO. Here, a minority of scientifically trained stakeholders, specifically those with a strong voice, developed a dislike for the scenarios. Our understanding is that a possible reason was that they were empowering a wider audience to participate and contribute to debate and policy. Some of the scenario content challenged their existing mindset by introducing a societal, non-scientific, dimension. The external advisory body of the IAEA saw the described scenarios as having more negative implications than positive ones, suggesting (constructively) that future scenarios include more situations impacting the Department's work positively, for balance.

Overall however, the dominant feedback loop was a positive one from external scientific stakeholders that established thought leadership in the domain. The public scenarios of both the EPO and RSC were widely propagated and used by other scientific organisations. In the case of the EPO, the scenarios were used in other regions of the world and even translated (e.g. into Japanese). The RSC, as an industry association, saw their scenarios being used both within its membership and more broadly with industry, and we understand from recent (December 2019) interviews that they are still being explicitly referred to.

E. External Non-Scientific Stakeholders

Each of the three organizations found, thanks to undertaking scenario planning, to have had something like blind spots in terms of their respective awareness of their operating environments. The three organizations are dominated both internally and externally by scientific stakeholders, including in the governance models of both inter-governmental organisations. In the case of both the EPO and the RSC, the blind spots were surfaced during a structured interview process which incorporated external non-scientific stakeholders. Table 4 summarises how this was the case for each organization and how these stakeholders considered the scenario planning which was undertaken.

Table 4 here

OUTCOME AND IMPACT COMPARISON

Besides the comparison from the stakeholder perspective, it is important – especially for the practitioner readers – to examine what resulted from the introduction of scenario planning: the core outcomes of the scenario sets (summarized in table 5) and, even more importantly, their impacts on the respective organizations (summarized in table 6).

All three organization produced a set of four scenarios. With their scenario planning all three organizations recognized the significance of the broader trends and actors outside their immediate transactional environment and of their own scientific or technological domains. For example, the IAEA's scenarios examined not only the future of the nuclear industry itself but also the broader technological environment and its impacts on the organization's verification work. In the case of the EPO it was the scenario dealing with geopolitics that had the biggest impact, changing the offices with which the EPO met to consider IP work. Of the three cases, the RSC's scenarios were perhaps most internally focused, as the very motivation was to understand the future of chemistry itself – though it too had to assess the links between chemistry and other fields such as big data analytics, AI, and biology.

Table 5 here

In terms of the impacts of introducing and using scenario planning, at the EPO scenario planning contributed to the strategic renewal inside the patent system, leading to certain initiatives, including strengthening institutional collaborations among different countries' patent offices. In the IAEA, some takeaways from the scenarios were incorporated into the organization's strategic plans, particularly as they relate to engagement and partnerships with stakeholders. The organization has since also sought greater external expertise to understand the impacts of emerging technologies. At the RSC, scenarios are resulting in new plans for chemistry education and scholarly communication.

One notable observation is that, in all three cases, the scenarios seem to have sparked new thinking with respect to interactions with 'external' parties, highlighting the importance of closer cooperation and engagement of the various actors in the transactional environment if the organizations are to survive the increasing turbulence of their operating environment – perhaps offering an important observation about growing inter-dependencies in an ever globalized world.

Table 6 here

FINDINGS AND CONCLUDING REMARKS

We have sought to propose a way in which theory can be tentatively advanced through abductive reasoning used in reflection on practice: “Qualitative research serves a powerful role in the creation of knowledge in management scholarship...” (Pratt et al, 2019, p. 2).

The results of our work are propositions, not tested affirmations: “By qualitative research, we mean inductive or abductive scholarship that does not test theory and that “produces findings not arrived at by statistical procedures or other means of quantification” (Strauss and Corbin, 1998: 10; cited in Pratt et al, *ibid.*)

There are limitations that this form of abductive qualitative research based on reflection on practice inevitably entails: “Scholars may be consuming qualitative work in ways that were never intended (e.g., as containing findings that are roughly equivalent to theory testing). These misunderstandings may tempt deductive scholars to critique the practices of qualitative researchers from their own epistemological lens, which will shape their normative views about best research practices. Yet trying to make qualitative research fit the assumptions of deductive positivism could hinder theory building and elaboration, thus undermining the key strengths of inductive, qualitative methodologies ...(including) what the work seeks to accomplish ...i.e., theory building and elaboration rather than theory testing (Pratt et al, *ibid.*, p.3)...What qualitative research can contribute in this open-systems world is twofold: first, caution about the kinds of hard-and-fast rules that faith in regularity tends to promote; and second, rich theoretical and conceptual repertoires to help managers deal with each unique circumstance that confronts them (*ibid.*, p.6)”

When Funtowicz and Ravetz proposed the post-normal science’ construct in 1993, the main rationale for it was that they considered that science requires an ‘extended peer community’ to validate its work. Meeting this requirement, they argued, would enhance the quality and robustness of the ‘strategic conversation’ (van der Heijden, 2005) among science and policy makers and others whom science serves and depends upon.

Our understanding of the three cases we have presented and analysed is that this prognosis, made almost thirty years ago, has come to pass. Indeed, we understand the three scenario planning engagements we have researched to be separate but comparable instances in which leaders in science-based or science-centered organisations have understood the need to extend the peer community so to contribute to the viability and relevance of their organizations.

But the extension which the leaders of the three organisations undertook with the help of scenario planning included an extended dimension which Funtowicz and Ravetz had not foreseen. Indeed, the choice of scenario planning as a relevant methodology in effect extended the peer community to a broader set of views now also extended in time (Adam, 1998) over which validation can be considered. By looking at the present decisions from future perspectives, scenario planning changes the framing of what it helps to evaluate (Ramirez and Wilkinson, 2016).

We have surveyed the challenges of launching and doing scenario planning in science-based and science-centered organisations as well as the results obtained in doing so. With the help of these three cases, we have also seen that training in world-class science and positivism, are not barriers to using scenario planning as a methodology to help in strategising.

As a better understanding of how these challenges compare to those of scenario planning done in commercial organizations becomes available (Ramirez et al, 2017), one would expect more scientific endeavors to use more scenario planning as turbulent conditions take hold of the fields in which they operate.

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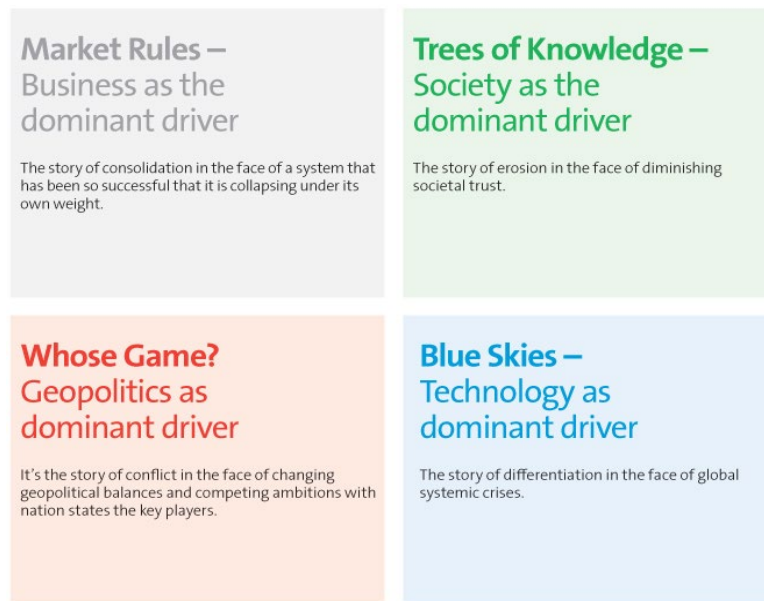


Figure 1 – The four IP scenarios (source EPO)

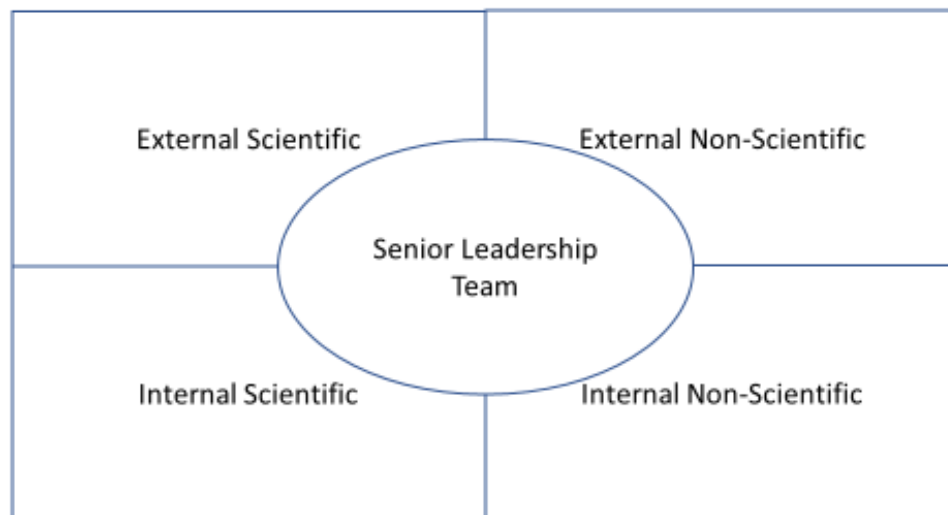


Figure 2 - the five elements of each of the three case studies

Table 1: Reasons to launch scenario planning

Reason	IAEA	EPO	RSC
Timing & Turbulence, unpredictability –	<i>2016. Desire to be prepared for a wider set of alternative futures, to enhance preparedness</i>	<i>2001. Different economic use of patents and changing face of technology</i>	<i>2014. Changing nature of chemistry</i>
Complement shortcomings in existing planning	<i>Yes. Scenario planning opened up wider contextual analysis, stimulated strategic thinking and analysis of risks.</i>	<i>Yes. Existing planning was workload focused. The scenarios helped deepen the risk thinking.</i>	<i>Initially no. Scenario planning was a part of a broader future orientated enquiry that sought to ‘nudge’ leaders, but the scenarios were later used to improve planning.</i>
Challenged by non-scientific stakeholders	<i>Yes. Atomic energy is a technology impacted by the worlds of politics, security and economics.</i>	<i>Yes. Gene patents especially brought in non-patent, non-scientific (ethical) stakeholders. Also concern about economic direction of patenting.</i>	<i>Yes. Chemistry shifts from being a scientific solution to also be the source of (environmental and other) problems.</i>
Link to organizational strategy	<i>Yes. Scenarios were developed to inform the organization’s strategic plan.</i>	<i>The economic purpose and risk thinking that emanated from scenarios became integrated into EPO strategy.</i>	<i>Yes, scenarios informed RSC’s long-term strategy.</i>

Table 2: Features of scenario planning

	IAEA	EPO	RSC
Education of training on scenario planning in the organization	<i>Two-day workshop for mid-level managers and a condensed 2-3 hour session for the senior management team.</i>	<i>Yes. Extensive.</i>	<i>No. One day workshop to decide to use SP, followed by a multiphase scenario planning programme.</i>
Method used	<i>Inductive method</i>	<i>Inductive method</i>	<i>mixed</i>
Number of external expert interviews	<i>In-house exercise to build scenarios</i>	<i>More than 100</i>	<i>Around 50, although all were RSC members</i>
Exposure of scenarios to external stakeholders	<i>An IAEA advisory body. Some aspects arising from the scenarios were explored in a symposium with 800 external stakeholders (mostly scientific)</i>	<i>Several thousands (multiple workshops, public presentations ...)</i>	<i>10's of thousands (all members) and many industrial stakeholders and journalists</i>

Table 3: Staff in science-positions and their role in scenario planning in each case

	IAEA	EPO	RSC
Number of scientifically trained staff/members	<i>Vast majority of the Department of Safeguards' staff²¹</i>	<i>5000 out of 7000 staff</i>	<i>60,000 members</i>
Development of and/or use of scenarios by internal scientific staff	<i>Senior management team, including Department head; expert staff from all parts of the Department</i>	<i>Senior management team, policy staff, scientific experts, planners and departmental heads</i>	<i>Senior management team and scientific and professional experts in the workshops. Shared with all members.</i>
Main reactions to the scenarios and the approach from scientific in-house staff	<i>Desire for evidence by those not involved in developing them. Expert facilitation and views essential for credibility.</i>	<i>Getting the patent terminology correct. External expert views essential for credibility.</i>	<i>Expert views from across the whole field (including Nobel Prize winners) essential for credibility.</i>

²¹ <https://www.iaea.org/about/staff>

Table 4: External non-scientific stakeholder characteristics for each organization and their reactions to scenario planning

	IAEA	EPO	RSC
Main type of non-scientific external stakeholder	<i>Diplomats, Regulators, Lawyers</i>	<i>Economists, Lawyers, Industry</i>	<i>Industry, Academia</i>
Blind spots that were revealed by scenarios	<i>Speed and impacts of non-nuclear technologies (e.g. AI), and the potential rise of new actors in the field of verification</i>	<i>Chinese and Korean IP as emerging, major actors. The changing use of IP. IP as a manager of risk.</i>	<i>Computational techniques, IP, market and social factors.</i>
Exposure of external non-scientific stakeholders to scenarios	<i>Limited as the scenarios were developed for internal planning purposes.</i>	<i>Extensive. The scenarios were launched in front of Chancellor Merkel to coincide with her keynote on transatlantic co-operation and the EPO's 30th anniversary</i>	<i>Extensive. RSC is sharing the scenarios with government, funders and society at large.</i>
Reaction of external non-scientific stakeholders to scenarios	<i>Not applicable</i>	<i>Non-scientific stakeholders embraced the scenarios as a way to engage with IP professionals as equals. The IP world had been seen as being an ivory tower and the scenarios opened it up.</i>	<i>Positive through industry / business conferences and road-show presentations</i>

Table 5: The core outcomes of the scenarios in each case intervention

	IAEA	EPO	RSC
Scenario 1	<i>The evolution of the nuclear industry</i>	<i>Market rules – business is the dominant driver</i>	<i>Chemistry meeting global challenges</i>
Scenario 2	<i>The impact of non-nuclear technologies (e.g. additive manufacturing, AI) as challengers and enablers</i>	<i>Blue skies – technology is the dominant driver</i>	<i>How chemistry may change as a practice</i>
Scenario 3	<i>The dark side of new technologies (e.g. cyber threats)</i>	<i>Trees of knowledge – society the is dominant</i>	<i>Fragmentation of the chemistry profession</i>
Scenario 4	<i>Status of the nuclear non-proliferation regime as a whole, including policy aspects</i>	<i>Whose game – geopolitics is dominant</i>	<i>Impacts of reduced public funding on chemistry</i>

Table 6: The impact of the scenario interventions

Impacts observed	IAEA	EPO	RSC
Initiatives following the production of the scenario planning set	<i>A series of actions incorporated into the organization's strategic plan, and decision to strengthen the monitoring of emerging technologies.</i>	<i>Decisions including on institutional collaboration among patent offices; a patent classification scheme; and an 'Inventor of the Year' award. Risk management approach to quality improvement.</i>	<i>Plans for new programs on chemistry education and scholarly communication.</i>
Role of scenario planning in institution's strategy	<i>The IAEA has integrated scenarios into its planning methodologies and continues to update them</i>	<i>While the scenarios continue to be used in the world, there has been no longer-term follow-up in EPO</i>	<i>The original set of 2016 scenarios continue to be used</i>