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How plausibility-based scenario practices are grappling with complexity to appreciate and address 21st century challenges

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ABSTRACT

Scenarios are best described as a highly innovative, pragmatic field of practice grappling with theoretical grounding. Complexity science, in contrast, is a theoretically grounded, highly conceptual field searching for more effective and extensive application in practice. This paper explores how these largely separate fields might be better related in enabling groups and organizations cope with uncertainty. It focuses on non-probabilistic scenarios and the so-called Intuitive logics school of scenarios, with its emphasis on plausible, alternative futures because of its increasing dominance. The benefits of incorporating key insights from complexity science into scenario practices seems an obvious 'must have' in engaging complex, messy and puzzling situations and guiding action in the 21st century. Similarly, the persistent and recent significantly increased interest in scenarios offers insights relevant to extending complexity ideas beyond academe and inquiry, into broader spheres of corporate strategy, public policy-making and change management. Plausibility-based scenarios are being deployed to grapple with complexity for a variety of different purposes, including strategic renewal, anticipating systemic risks and enabling the large scale, transitions implied in meeting the challenge of global, sustainable development. This paper suggests that intuitive logics scenarios offer an 'on-ramp' to complexity, encouraging attention to the systemic framing of systems, situations and problems and enabling complexity concepts to penetrate beyond the domains of scholarship. It notes that complexity thinking challenges one-off scenario building practices, especially when the scenarios are developed using the deductive building method. As plausibility-based scenario practices continue to evolve they encounter practical challenges of *linking* to other processes, *relating* to other futures methods, *broadening* beyond the organizational scale, *engaging* heterogeneous agents and in enabling *deeper reframing*, exposing deeply held beliefs about progress and assumptions about change management in complex systems. This paper concludes with implications for practice and future scholarship associated with each challenge.

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1. Introduction

Policy and decision-making would be simpler if cause and effect in natural and human systems could be clearly understood. Small changes would have small effects; large changes would have large effects; what worked in the past would work in the future. The success of scenario practices in enabling constructive engagement with uncertainty is evident in their persistent use in public policy and corporate strategy for over 50 years. Complexity science is a more recent development and introduces new concepts, such as emergence and self-organization, to deal with uncertainty.

In this paper, we explore how these largely separate fields of practice and theory are co-evolving and how key concepts and tools relate. We are aware that investigating the connections

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between these two fields presents the danger of breadth at the expense of depth. We take on this challenge and argue that better understanding and blending between these practice-led and theory-led fields is beneficial to both.

The paper is structured as follows: in Section 1, we introduce non-probabilistic scenario work and explain our focus on the so-called intuitive logics school of scenarios, before succinctly introducing complexity. In Section 2, we review relevant literature and suggest connections between plausible scenario work and complexity science can be made on an ontological, epistemological and methodological basis. In Section 3, we introduce a new typology to recognize the diversity of purposes and settings in plausibility-based, scenario practices. We used this framework to select four cases to show how scenario work is continuing to evolve as it grapples with complexity. In Section 4, we discuss our findings and we draw our conclusions and recommendations for scholarship and practice.

1.1. Interconnectivity and irreducible uncertainty

The tighter interconnections of natural, social and economic systems lead to increased uncertainty and greater complexity. The growing list of today's significant concerns, whether focused on fixing the financial crisis or progressing socio-ecological sustainability highlights the urgency to look forward and manage large scale, system transformations [1] and challenges the conventional western economic wisdom of continuous, linear or exponential growth. Failure to engage with irreducible uncertainty is more widely appreciated and attempts to tame uncertainty can make matters worse [2].

Appreciation of a complex, less predictable world has been met by calls for new approaches to how we understand, organize and enable progress through the creation and application of policy. Suggestions include 'future responsive social learning' [3] in order to cope with challenges and changes variously described as wicked problems [4], social messes [5] and turbulent changes [6].

1.2. Scenarios as a response to a more complex and uncertain world

Scenarios were introduced over 50 years ago as a means to overcome the limits of linear, reductionist and deterministic thinking that underpinned the then dominant practices of forecast-based planning. Scenario builders reject the notion of wholly predictable futures and instead seek to construct alternative futures which explore not only the paths to each, but do so in a way that emphasizes the need to attend to disruptive change as normal. Scenarios work is conducted in different sectors – public, private, civil and academia – and for a wide range of purposes, such as learning [7], strategy [8], or conflict avoidance [9].

Scenario practices have evolved from a "hypothetical sequencing of events constructed with the purpose of focusing attention on causal structures and decision points" [10] to attendance to the dynamic interactions that create disruptive and turbulent change as organizations co-evolve with their wider contexts [11]. At the same time, continuous innovation and diversity of scenario practices result in methodological confusions and misunderstandings [12]. To avoid contributing to further confusion we first define and then justify our interest in one particular tradition of practice.

Bradfield et al. [13] highlight three different scenario 'schools'. In this paper we focus on what those authors refer to as *Intuitive Logics*, with its emphasis on *plausible* alternative futures, in contrast with the normative *French School* and the probabilistic *USA School*. Our choice to focus on the intuitive logics school is justified by evidence of its growing dominance in non-probabilistic scenario work [14].

Schoemaker [15] describes how plausibility-based scenarios are useful approaches in situations characterized by increasing uncertainty and complexity. He notes the effectiveness of scenarios as a psychological basis for addressing biases due to cognitive limits and overcoming 'group think' resulting from consensus building processes in social organizations.

In the intuitive logics tradition, the future is a fiction. Scenarios are 'open stories' [16] and stories and storytelling are deployed as a means to engage intuition, expose deeply held assumptions and forge new and shared interpretative frames. The assumption is that the emerging future cannot be forecasted but can be imagined and "lived in" and offers a different perspective to learning about the present than history alone provides. In effect, plausibility-based scenarios offer reframing devices rather than forecasting tools [17,18]. Scenarios are not populated with facts but with perceptions, assumptions and expectations.

Quality of a good scenario is not determined by its predictive accuracy but by its impact which can be evaluated in different ways — cognitive shift, enhancing judgment, leading to more and better strategic options and/or motivating change [19].

Despite the extensive and continued use of intuitive logics scenarios in the public and private sectors, the diversity of methods can lead to a wholesale dismissal of these practices by empiricist traditions of inquiry and evidence-based decision making cultures [20,21]. At the same time organizations, such as Shell, which have sustained the practice of plausibility-based, intuitive logics scenarios for over 50 years, appreciate the added value in terms of enabling decision makers to engage with uncertainty, enabling systemic insights and contributing to the adaptive capacity of the firm [21].

1.3. The promise of complexity

Complexity or the 'science of complex systems' has raised expectations about new abilities to address problems in fields as varied as biology, traffic regulation, stock markets and urban warfare [22]. Computer-based experiments to reproduce complex system dynamics from a set of relatively simple rules at the system' components level became a powerful method for studying systems that were not resolvable analytically [23]. Increasingly, complexity is an accepted but still emerging discipline, with most universities fielding research programs. Still, the field has struggled to make an impact on public policy.

While there are no universally accepted definitions of complex systems, they are best grasped by listing characteristic elements: a large number of heterogeneous agents, which influence each other's inner state and have a high sensitivity to initial conditions. This leads to non-deterministic and unpredictable system behavior, driven by feedback loops between individual agents, as well as at various levels in the system [24].

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The core mechanism of the emergence of order in complex systems is evolutionary and adaptive: "All the order and complexity, all the knowledge was created and assembled by the simplest of recipes: differentiate, select, replicate, and repeat" [25].

Prigogine and Stengers [26] describe a thorough and sweeping framework for how order in complex systems can emerge from chaos through self-organization.

An early example of this approach is Thomas Schelling's groundbreaking insight into social segregation [27]. This demonstrated the mechanism whereby slight racial preferences ("micro-motives"), could lead to strong segregation ("macro-behaviors"). Later, with the advent of low-cost computing, the study of complex systems offered the opportunity to simulate, with mathematical rigor, systems that were hitherto largely intractable.

Complexity has been most successful in analyzing complex systems whose characteristics are captured in stylized facts at system level based on agent-based models, offering a laboratory to study their dynamics quantitatively. Although often crude, these models can yield rich insights. Yet complexity has become a mainstream approach in limited policy areas, such as traffic regulation [28], logistics or epidemiology [29]. Elsewhere it remains at odds with mainstream traditions that are generally grounded in more reductionist approaches. In policy considerations, complexity is still often referred to as something undesirable to be reduced and eliminated, rather than a source of order [30].

2. Review of relevant literature

Conducting a comprehensive review of literature on scenarios and complexity science is not straightforward due to the fragmented communities and journals associated with each, the continued evolution of the intuitive logics tradition and still emerging nature of complexity science. In this journal alone, there have been 160 articles since 2007 referencing scenarios work and complexity terms with few exploring the matter of relatedness in any depth. In this section we focus on a handful of articles that relate plausible futures thinking and complexity science in some depth.

Mannermaa [31] links complexity in conceptual terms to normative futures ("making the future") and notes [32] the emergence of an evolutionary paradigm in futures studies, with roots in the study of complex, self-organizing systems. This paradigm is contrasted with the 'established' scenario paradigm, which is characterized as deploying an implicit framing of linear and exponential views of development and thus a tendency to overlook sudden shifts in social development. It is not clear, however, which body of scenario literature and/or practices was reviewed to form this characterization of the 'established' scenario paradigm.

Linstone [33] explores the implications of complexity science for forecasting and while confirming inherent limits on the mathematical describability, computability, and predictability of complex systems suggests complexity science strive to find ways to help policy makers engage with nonlinear change.

Burt [34] integrates Christensen's theory of disruption and system analysis with the scenario methodology to develop a framework that provides an understanding of the underlying systemic conditions that create disruption and/or discontinuity. Observing the limitation of systems analysis, he notes "Understanding the totality of the system is not possible, due to the large number of variables, and the resulting complexity". It is possible, however, to understand 'chunks' of variables and their relationships, known as 'bracketing' [35], through the identification of feedback loops.

The role of scenarios in grappling with the uncertain and complex nature of socio-ecological systems and global environmental challenges is evident in the future literature. For example, Alcamo [36] notes the hybridization of qualitative, plausibility based scenario work and quantitative, integrated assessment modeling in helping policy makers grapple with complex and uncertain environmental challenges, such as climate change.

van Vliet et al. [37] note that scenarios have to bridge the gap between incorporating large uncertainties and maintaining plausibility. These authors note the challenge in engaging multiple and diverse stakeholder interests at multiple scales in exploring change in complex socio-ecological systems and suggest the use of Fuzzy Cognitive Maps – a semi quantitative method – to facilitate more effective communication between stakeholders and modelers. Zurek and Henrichs [38] explore the role of scenarios in appreciating complex socio-ecological systems and raise the issue of cross-scale consistency and comparability before going on to suggest five different ways focused scenarios might be coupled across geographical scales. They note that scenario-based approaches are particularly useful when addressing the considerable uncertainty about future trajectories in complex systems, and often this makes it necessary to reduce the complexity of systems before analyzing them, either by looking only at parts of a system or by focusing on a very concrete focal question in the scenario process.

Eriksson and Weber [39], using a complexity view, attempt to achieve a conceptual consolidation of 'adaptive foresight' favoring a more modest interpretation of the collective ability to "shape the future" and stressing the need to adapt to actions by others.

Robinson [40] harnesses qualitative scenarios as a tool for exploring nanotechnology governance arrangements, in an attempt to enable multi-stakeholder anticipation of the complexities of the co-evolution of technology and governance. He notes that the creation of the scenarios embraced complexity by referring to the emerging natures of both the innovation chains and their environment. He suggests that scenarios enable a grip on complexity — through actors pro-actively shaping chains and governance, and through lock-ins and selection.

Franco et al. [41] use complexity science to help identify interdependencies and encourage greater involvement of workshop participants in scenario planning activity. These authors note the cognitive diversity of the workshop participants as a critical determinant of the effectiveness of scenario planning interventions.

Haan and Rotmans [42] reframed and expanded, from a complexity view, a role for normative scenarios in transitions in societal systems. Sondereijker et al. [1] see scenarios as part of the emerging toolkit for "steering and coordinating large scale systems innovations towards greater sustainability".

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In terms of literature that relates complexity thinking with plausible scenarios and specifically the intuitive logics school of scenarios, Pierre Wack [7] explores the link between the Causal Textures Theory [6], an approach to complexity developed by Emery and Trist and originating in the field of social ecology, and notes causal textures arising from outcomes of the interaction between interrelated actors and driving forces and how scenarios make it possible to investigate and identify them and the unfolding consequences for the organization.

Burt et al. [43] further develop this link but harness a system dynamics rather than a complex system interpretation of Wack's pre-determined elements to suggest predetermined elements as a precursor to developing an understanding of a new contextual reality that ultimately should lead to new organizational action.

Ramirez at al. [44] also address the link between the Causal Textures Theory and scenarios and describe how scenarios assist in anticipating turbulent change. In conditions of turbulent change the adaptive capacity of individual organizations is overwhelmed by changes in the wider environment.

Selsky et al. [45: 291] state that macro-evolution and strategic choice can be reconciled and that a strategy to escape turbulence involves the formation of a collaborative enclave that "will provide further insights that link micro-actions and decision *in* a field with macro-evolutionary trajectories *of* that field".

Bernard [46] compares the Causal Textures Theory with the work of Prigogine [47] on complexity and self-organization, noting that both sets of scholars did not present a view of chaos as 'value free', but included consideration of values and hope.

2.1. Comparison of ontological and epistemological foundations

In contrast with the objectivist and positivist ontologies of probabilistic scenario practices, constructivism, nominalism and post-normal science are the mainstays of the plausibility-based, intuitive logics tradition [10,12,48,49]. As Burrell and Morgan [50] noted, a realist sees the nature of reality as 'out there', hard and concrete, while the nominalist sees the social world as the result of individual cognition and made up of names, labels and concepts. Wilkinson and Eidinow [12] note the objectivist–constructivist dichotomy between probable and plausible scenario traditions. Scenarios are pragmatic rather than positivistic: events and behaviors are explained from the perspective of the individuals involved and thus reflect equally valid understandings from multiple points in a system. A central challenge is thus to navigate plurality [51] (Table 1).

For many complexity practitioners, the science of multi-level interconnected systems is extending the boundary of uncertainty where quantitative analysis is applicable. Agent-based modeling is one of the new techniques being used to undertake quantitative assessment of the probability of the collapse of system resilience [52], enabling a statistical forecast of the transition between various regimes of the system. Such approach proved relevant in addressing instabilities in financial markets and the role of contagion of norms as proposed by Axelrod [53], or Gintis [54] in the reframing obesity as an epidemic [55] rather than induced by the marketing of dubious foods.

Table 1
Comparison of philosophy of scenarios and complexity.

	Intuitive logics scenarios	Complexity
Ontological stance	Critical realist and constructivist Nominalist — sees the social world as a result of individual cognition and made up of names, labels and concepts	Realist — enables better definition of the boundary of uncertainty
Epistemological stance	Pragmatic Post Normal Science — engaging with framing disputes and values conflicts	Positivist Mode 1 Science — extending the boundary where technical analysis can be applied [50]

Paul Cilliers [56] reflects on the ontology of complexity as follows: "The argument from complexity thus wants to move beyond the objective/subjective dichotomy". He goes on to say that complexity science is in some ways an extension of the traditional scientific approach, but the ontological issues are shifted to the problem of boundaries. Since complex systems are open systems that interact with other systems, the choice of boundary is arbitrary. He quotes the notion of 'operational closure' as a useful approach, rooted in pragmatism. The uncertainty on the state of the system in the future is therefore objectively bound by formal mathematical modeling, but at the same time subjectively framed through the (explicit or implicit) choices concerning critical systems heuristics e.g. definition of the system boundaries.

2.2. Methodological comparison: relating scenario practice elements with complexity concepts

Elements of the intuitive logics tradition in scenario practices can be related to core concepts in complexity. We demonstrate this by reinterpretation of three core elements of the scenario practice in the language of complexity.

2.2.1. Pre-determined elements as lock-ins

A set of plausible scenarios is built from the combination of critical uncertainties about the future, in a way that reveals deeply held assumptions and draws attention from the continuity of linear change to potential discontinuities. As part of many scenario exercises an inventory is also made of elements that are the same in any of the futures. Pierre Wack [57] defines predetermined elements as events that are already in the pipeline and will emerge in the future as a series of interrelated actions that will together be co-producing a particular outcome.

Sometimes a pre-determined element refers to a simple causal correlation between facts, such as the depletion of finite natural resources. It implies an invariance of outcomes, interplay or factors and, as such, is a simplification that encourages attention to what might be assumed constant across all possible futures within the selected time horizon.

In complexity, lock-in refers to properties of a system that become fixed endogenously. A lock-in is not necessarily permanent, but may simply have a high barrier to change. This is a richer concept than a pre-determined element that is taken as immutable and given. By interpreting pre-determined elements in a scenario in terms of lock-ins, one would focus

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attention on those changes that would cause the lock-ins to unwind, instead of considering them as given. In complex systems, most often this will consist of multiple small prods, rather than a single large cause.

2.2.2. Focal question as fitness criteria

In inductive scenario building, the focal question emerges after the scenarios are built, and is refined through several rounds of iteration between intuition and analysis.

Fitness is an essential concept in the emergence of order in complex systems. Gavrilets [58] describes how from Darwin's ideas of evolution, it evolved into the broader notion of fitness landscapes. Kauffman and Johnson [59] applied the idea to complexity and describe the optimization of the fitness-function core to the adaptive evolution of complex systems.

So how does the concept of fitness optimization map onto scenario practice?

In complex situations the choice of focal question needs to open up rather than close down the problem frame and reveal and test otherwise implicit assumptions about the nature of the complexity dynamics in the system under consideration.

In some scenarios there is an implicit parameter around which the envisaged future is optimized, thus pre-determining the dynamics of the system. For example, in the WBCSD water scenarios [60], each of the three scenarios has a different fitness criterion. For one scenario, it is *eco-efficiency*, for another scenario, it is *conflict avoidance* and *social stability* and for the third scenario, it is about *system-wide resilience* — the capacity to co-evolve with other systems. As such, scenarios help to highlight the fact that the fitness criterion that is chosen can reflect the choice of frame, rather than be given a priori.

For another example, "The Oxford Scenarios: Looking Beyond the Financial Crisis" [61], was designed to open up questions about the nature of the crisis and, in turn, assumptions about the nature of the underlying systems. These scenarios focused on revealing and testing deeply held assumptions about the relationships between the financial system, real economy and wider world, in effect contrasting the neo-classical economics perspective with one of evolutionary or ecological economics.

These two examples show how scenarios in the intuitive logics practice tradition can provide an "on-ramp" to framing and reframing complex situations and challenges.

2.2.3. Branching points as representations of phase transitions

In the tradition of intuitive logics scenario work, the branching points are the points where a critical uncertainty can unfold in different directions. Each branch therefore suggests a different answer to the focal question; it is the process of growing different branches that will form the backbone of the stories.

In a complex system the dynamics are driven by the interaction between individual agents. Over time, the cumulative effect of these continued feedback dynamics causes the emergence of novel system level behavior and states. Sometimes the emergence of a new system state can be very rapid. Such sudden, non-linear transitions to a different and discontinuous state are known as phase transitions.

Vasileiadou and Safarzynska [62:15] state that in "complex systems, because of the non-linearity and negative feedback loops, system-level variables are expected to undergo random fluctuations. In such systems, it may be difficult to identify transition points. Therefore, we may need enough data points for conducting a longitudinal research design, and a retrospective analysis. A short-term, concurrent research design runs the risk of wrongly diagnosing the stage of a transition process." While clear indicators of the advent of a phase transition in complex systems have been identified – loosely analogous to the bubble formation in a kettle of water just before the boiling point is reached – in most futures studies, there will be insufficient data to use complexity-based modeling techniques.

The branching points in scenarios, therefore, can be seen to be a highly stylized and somewhat symbolic representation of the state selection that occurs during the evolution of complex systems. Branching points in scenarios can be seen as an analogy with phase transitions rather than an event-based causal consequence. An example of the former would be peace in the Middle East from the effect of good governance in the East Bank, and an example of the latter would be a new conflict in the Middle East from the bombing of Iran by Israel or vice-versa.

2.2.4. Key driving forces and weak signals in the light of emergence

A reference point in scenario work is the definition of key driving forces. A somewhat unfortunate translation of "tendances lourdes" coined from Fernand Braudel by Pierre Wack [63]. It is perhaps more accurately and evocatively translated as "sticky trends". The very concept of macro forces determining an outcome is a reflection of an underlying assumption of the dynamics of the system i.e. assuming proportionality between cause and effect. This assumption also underlies Systems Dynamics which highlights system level feedback mechanisms [64]. A clarification in complexity is that feedback at multiple scales can lead to additional emergent system behavior driven from small causes ("micro causes" to "macro effects"). An example can be found in micro-credit, where embedding a loan in the social structures surrounding the borrower, by getting his/her close network to guarantee the loan, is a micro-effect leading to emergent behavior of much higher repayment rates than an assessment of the macro forces at play would have implied. A system dynamics analysis would have listed risk categories and overlooked the crucial scaling element.

It is worth noting that the term 'weak signals', as used in scenario work, is a different concept from the types of micro-causes we are discussing here. Weak signals represent novelty and signposts of discontinuous change in scenario work. As such, they represent the early stages in the development of a subsequently stronger, continuing trend, without any assumption on the causality of scaling from the individual occurrence to the broader impact.

The complexity view suggests that one needs to not only look at key driving forces as shaping the future, but also critically look for micro causes that could have a determinant influence on the future through an emergent effect. Scenario practice uses both strong trends and weak signals. However, we emphasize that weak signals are different from micro-causes, as their relevance is in their potential to grow into a key driving force over time. Including micro-causes poses a substantial challenge to scenario work, as one asks whether these micro causes are detectable and also how to distinguish those that are relevant from the background noise of small effects? As illustrated in the

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micro-credit example above, an indication is to look for weak feedback loops that can collectively build up to a powerful emergent effect. While this recipe is unsatisfactory, it is not *in principle* different from the intuitive capacity described by Van der Heijden et al. [65] that is tapped during the scenario work to identify the key driving forces.

2.3. Synergies and tensions

The world of plausibility-based, intuitive logics scenarios, we suggest, is best described as a highly innovative, practice-led field grappling with theoretical grounding. It engages with uncertainty and complexity in terms of revealing and testing assumptions and expectations about the future that shape an understanding of the present. Complexity science, in contrast, is a theoretically grounded, highly conceptual field searching for more effective and extensive application in practice and dependent on data-driven analysis.

We suggest despite these differences, communities of scholars and practitioners in scenarios and complexity have common cause in their mutual struggle with the limits (and near hegemony) of reductionism in the policy-making process. We suggest scenarios and complexity share a common cause in grappling with irreducible uncertainty and attending to nonlinear and disruptive change. They also have common cause in overcoming the false dichotomy of quantitative verses qualitative inquiry and analysis.

Looking at the scenario process itself through a complexity lens, it consists of the familiar steps of *differentiate* (generate alternative future contexts through induction), *select* (reduce and sort for plausibility), *learn* (observe and track milestones and indicators) and *repeat* (the next round of scenarios). In addition to framing scenario work in terms of an evolutionary process, several concepts in the intuitive tradition of scenarios lend themselves to reinterpretation from a complexity perspective.

By maintaining the future as a fiction in which alternative narratives can be revealed and respected, a set of scenarios enables reframing by providing a set of relevant, interpretive frames that spur reflexivity. Complexity models on the other hand focus on the realm of knowledge and help quantify, describe and bound uncertainty within a given frame.

Some complexity practitioners, however, have dismissed the wholesale potential contribution of scenarios as a way to get to grips with complexity [66]. In response we offer two observations. First, there are many different methods of building a set of plausible scenarios. Van der Heijden [20] highlights four scenarios building methods in the intuitive logics tradition – deductive-, intuitive-, incremental-, and visioning-based – and notes each has its strengths and weaknesses depending on the client and purpose of the intervention. He does not suggest any reject complexity. Second, the emphasis in the deductive building methods on structuring a set of scenarios using an a priori focal question and from the polarized interplay of a limited number of macro factors (i.e. drivers of change) can appear overly reductionist and ignore the potential for self-organization and bottom-up emergence. In practice, there can be an opportunity to learn between subsequent rounds of deductive scenario building i.e. to incorporate a feedback loop between top-down and bottom-up changes. Furthermore, complexity provides a new tool, agent-based modeling which can simulate the reactions of different agents to the different, extreme environmental conditions described in a 2×2 or 3×3 scenario matrix. This iteration between scenarios and agent-based modeling helps recognize that actors are not capricious but react, as well as contribute, to changes in their wider context. It is also worth noting that there is no single interpretation of the deductive method. For example, Klooster and van Asselt [67] uncovered four different functional meanings of a 2×2 matrix approach, based on an extensive ethnographic study of practice of the deductive building method and review of scenario literature.

3. A new typology of how scenarios grapple with complexity in practice

As a practice-led field, the evolution of plausibility-based scenario practices reveals insights about complex systems and offers learning that is relevant to helping complexity thinking penetrate beyond academe.

In this section we adopt a practice-based lens to show how plausibility-based scenario work continues to evolve to grapple with complexity and in doing so encounters new challenges in practice.

From a practical perspective, the first challenge is to find a relevant way to structure the diversity of practices. There are an increasing number of typologies focused on plausible scenarios and delineated by purpose — e.g. project goal characteristics [68], motivation [69] and preactive/proactive stance [70]. There is also increasing attention to the different settings of scenario practices in others — e.g. multistakeholder 'problem-focused' and 'actor-centric' scenarios [12].

Combining these dimensions of purpose and setting we suggest a simple 2×2 typology, as shown in Fig. 1.

One axis reflects the different purposes in scenario practices of 'seeing' i.e. better understanding and new insights, allowing one to prepare for anticipated changes in the future environment, versus 'seeding' the future i.e. generation of actionable options that if enacted will create the future, i.e. illuminating a future that might otherwise not happen. The other axis reflects the different settings of scenario work-organizational scale futures (i.e. single client focused — a company or a government) versus inter-organizational settings i.e. problem-centric, multi-stakeholder- and participatory-scenarios.

3.1. Shell scenario practices: single client focus, with a shift from seeing to seeding the future

Shell has pioneered and sustained the use of plausibility-based scenarios in a commercial setting from 1965 until today. Shell practitioners have always maintained an emphasis on plausibility as a basis for grappling with uncertainty and complexity, albeit without defining when, how and who determines plausibility. Shell practices have also evolved over a 50 year history and while the setting of the practice has not changed, a shift in purpose from 'seeing' to 'seeding' is notable.

3.1.1. Early years in Shell: seeing – or re-perceiving – the future

The development of scenarios in Shell grew out of a realization that long-term forecasting in business is too unreliable and a new approach was needed to cope with

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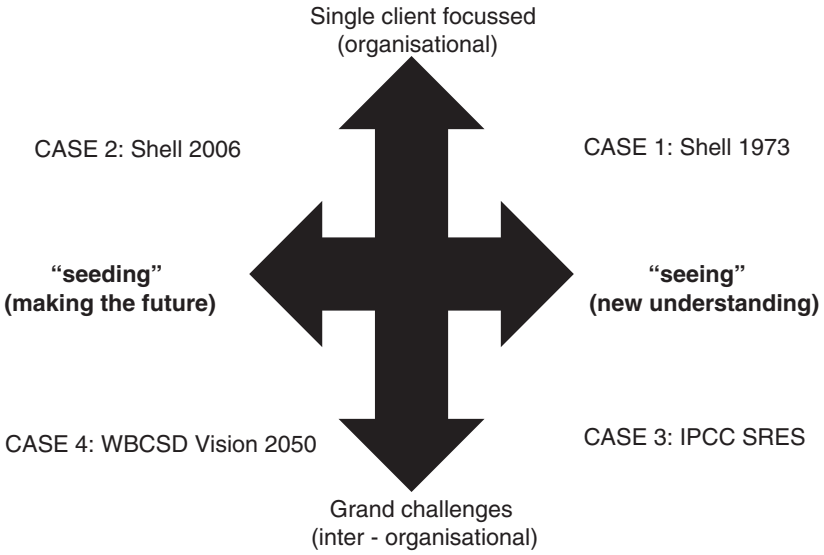

Fig. 1. One way to structure the diversity within plausibility-based scenario initiatives.

irreducible uncertainty and increasing complexity. One of the early year pioneers of Shell scenarios, Pierre Wack, stated: "Scenario planning is…aimed at…foresight in contexts of accelerated change, greater complexity and genuine uncertainty" [7: 150].

In the early 1970s, Shell was building scenarios to engage and challenge the mental models of the most senior group of Executives. The scenarios comprised a set of logical stories of cause and effect, describing how changes in the wider business context co-evolve with changes in the interactions of different actors e.g. Middle Eastern oil producer governments, importing states and private oil companies. In these early years, these 'macro' scenarios were presented to the Executives in a theatrical performance by the masterful storytellers that headed the in-house scenario team.

The scenarios were not discussed or used to generate strategic options, but over time were quantified using proprietary, computer models to provide illustrative indications of the implications of each scenario in the language of decision making.

Between 1973 and 1978 various sets of the macro Shell scenarios were developed highlighting the plausibility of a shift from business-as-usual growth, e.g. the disruptive potentials of a politically motivated oil crisis and the commoditization of oil.

In the 1980s, senior Shell Executives commissioned the scenario team to develop a set of scenarios to help them appreciate the meaning of 'sustainable development'. From the 1990s, the Shell scenarios have helped Executives in Shell explore and deepen their understanding of 'globalization'. In effect, the scenarios have helped establish a set of shared interpretative frameworks and, in turn, encouraging and enabling Shell Executives to 'see' the world anew — i.e. re-perceive the present situation using different paradigms and perspectives.

3.1.2. Later Shell practices: seeding the future with actionable options

By the mid-1980s, Shell had started to link scenarios with strategy: scenarios were linked in a wider process to strategic vision and competitor analysis in order to identify strategic options [7: 150 Exhibit V]. Shell scenario practices continued to evolve into decision support tools using real options theory [71] and to help link processes of innovation and strategy [72].

As the purpose of the scenarios changed from seeing (i.e. interpretive, pre-decision frameworks) to seeding the future (i.e. decision support tools), so the practice of scenarios continued to evolve to engage a wider set of decision makers into the scenario building process, to relate scenarios to the quantitative models, and to link the scenario process to others processes, e.g. strategy, innovation.

Throughout this evolution, Shell scenario practices have explicitly grappled with the issue of scale by recognizing that all of its scenarios are focused on a specific time horizon (6 months or 5, 20 or 50 years) and scale of system. For example Shell scenarios are denoted as 'macro' or 'global', 'energy', 'regional', 'long-term', 'medium-term' and 'short-term' or 'crisis' focused.

In linking with other processes, the Shell scenario practices have encountered the challenges of engaging a larger number of people and perspectives in scenario building and relating scenarios to quantitative models. The sequencing has been an intuitive-led inquiry using a combination of interviews and workshop-based engagement to enable an initial set of scenarios to be developed. Further research, over several rounds of scenario building enable iteration between the qualitative storylines and quantitative models. The models enrich and enhance the internal consistency of individual scenarios and help translate key implications of each scenario into the numerical language of decision making. In Shell practices, scenarios are related to models but not an extension of quantitative modeling, they are not 'of' the model, i.e. a sensitivity analysis of the assumptions built into a model.

In recognition of framing uncertainty inherent in its scenarios, Shell scenario practices appear to be grappling with the challenge of operating as an evergreen reframing mechanism. In 2012, Shell published a report, entitled Signals and Signposts [73]. This report indicates that Shell is actively monitoring its wider business environment to detect early warning signals that either confirm a particular energy scenario is emerging or to highlight that new signals

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are evident which imply the need to update or rebuild it energy scenarios.

3.2. IPCC scenarios: interdisciplinary inquiry engaging a mix of stakeholders and focused on the challenge of climate change

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. Since its beginnings, the IPCC has harnessed scenarios in its work and there have been several generations of practice. First generation IPCC scenario practices – called IS92 – were heavily influenced by probabilistic modeling. Scenarios were built as quantitative, model-based simulations and focused on delivering probabilistic projections of various greenhouse gas emissions. The models simulated physical impacts of climatic conditions on natural processes based on a few global variables representing increases in the atmospheric concentrations of greenhouse gases and the associated response of the climate system [74]. Probabilities were allocated to the different scenarios.

In the second generation – called the SRES process – scenarios were constructed by steering clear of allocating probabilities and focusing instead on the plausibility of the scenario set. The SRES scenarios comprise four narrative-based storylines – called A1, A2, B1 and B2 – each describing the wider socio-economic conditions relative to four ranges of emissions scenarios. The narratives are intended as reference or 'non-intervention' scenarios i.e. they seek specifically to exclude the effects of climate change and climate policies on society and the economy. The storylines combine two sets of divergent tendencies: (1) a policy focus on either strong economic development or strong environmental protection; and (2) a pattern of increasing globalization or increasing regionalization [75]. These storylines were translated into quantitative scenarios using integrated assessment models and simulations give rise to specific scenarios, depicting how economics, populations and technologies may change.

The second generation in IPCC scenario practices aimed to bring together different communities of uncertainty (qualitative, probabilistic) engaged in the IPCC process. Four storylines were first developed in the form of four different narratives on socio-economic conditions in the future. These were then translated into quantitative scenarios using integrated assessment models. However, this attempt to bridge different communities didn't fully succeed and qualitative scenarios and quantitative models kept developing to a great extent separately. This highlights the challenge of enabling effective engagement of more diverse stakeholders in challenge-focused scenario work.

One of the problems was the time taken between generating the four socio-economic narratives to the actual quantification of the climate impacts. In response to this problem, Moss et al. [76] proposed a new approach. These authors suggest changing the process to start with what is more certain from a climate science perspective, i.e. identification of radiative forcing characteristics that support modeling of a wide range of possible future climates. They propose that Representative Concentration Pathways (RCPs) selected from the published literature should provide the inputs of emissions, concentrations and land use/cover for climate models. In parallel with development of climate scenarios based on the RCPs, new socio-economic scenarios are to be developed to explore important socio-economic uncertainties. Subsequently, using a variety of tools and methods, the new socio-economic scenarios should be integrated with the new climate scenarios. This highlights the challenge of how to sequence and link scenarios and models.

While the IPCC SRES scenarios have been global in focus and addressed the problem of climate change mitigation i.e. emission reductions, the new process advocated by Moss et al. [76] would allow more diversity in the socio-economic realities and regional variability taken into account. It also enables focus beyond climate mitigation to include the challenges of adaptation and the impacts of climate change, which are expected to vary from location to location.

At the same time, the proposed change in process will also create new challenges determining the consistency and comparability of scenario work deployed by different users, operating at different scales.

It will be also interesting to observe if the next generation of the IPCC scenarios will engage new types of complexity-based modeling. There is the potential that scenarios become 'locked-in' to the present generation of climate models rather than engage with complexity modeling [77].

This case again emphasizes the point that scenario work in grappling with uncertainty in the context of unfamiliar and complex changes encounters new challenges of *relating* (e.g. scenarios and models), *broadening* (i.e. flexibility of focus of climate mitigation and adaptation, and global to local scales), *engaging* diverse stakeholders (i.e. different disciplines of science and policy makers), and in effectively *linking* scenarios to the policy-based, decision making process.

3.3. The WBCSD Vision 2050 Initiative: scenarios for seeding a global scale transition

The WBCSD is a CEO-led global association of some 200 companies which was founded on the eve of the 1992 Rio Earth Summit. Membership is open to companies committed to sustainable development and members are made up from companies in more than 36 countries and 22 major industrial sectors.

In February 2010, the WBCSD published a report, entitled "Vision 2050: The new agenda for business" [78]. The report is a consensus piece that was compiled by 29 leading global companies from 14 industries and focuses on a set of agreed must have needs to ensure change in the pace of progress sufficient to ensure sustainable development is 'on track' globally by 2050. It is the result of an 18 month long combined effort between CEOs and experts, and dialogs with more than 200 companies and external stakeholders in some 20 countries.

In the WBCSD Vision 2050 Initiative, visioning and backcasting were combined with scenarios and forecast-based modeling to develop illustrative quantifications of bio-capacity overshoot. This combination of methods was perceived by participants as fundamental to identifying concrete milestones relevant to the decision making timeframes of large companies [79].

The initiative encountered the challenges not only of relating different methods, but also of linking to the decision

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making process of individual member companies and broadening focus to encompass global, regional and industry sector developments while engaging with a diversity of participating and non-participating stakeholders.

Participants first outlined what they perceived to be a successful and sustainable future: the Vision 2050 was defined as the target "a planet of around 9 billion people, all living well within the constraints of the planet — with enough food, clean water, sanitation, shelter, mobility, education and health to make for wellness".

Then, participants identified 'business-as-usual' projections of a series of global mega-trends and the gap implied by these trends in terms of overshoot of bio-capacity by 2050. Using scenarios and data from existing sources, such as the International Energy Agency [80], United Nations Development Program and Environmental Program (UNEP), International Panel on Climate Change (IPCC) and harnessing the bio-capacity model of the Global Footprint Network (GFN), participants identified nine pathways that need to be progressed in parallel to keep progress towards sustainability on track by 2050.

Through a process of backcasting, i.e. a process of working backwards in time from the desired situation in 2050 implied by the vision, participants specify options for ensuring progress i.e. 350+ near term milestones and 40+ 'must have' actions.

In developing pathways, scenarios were also used to identify what could knock progress off track and, in turn, identify measures needed to counter 'big risks' i.e. developments beyond those assumed in the pathways.

By exploring the linkages between the nine pathways, new 'systemic' solutions spaces were identified and used to highlight the need for more cross-sectoral collaboration. Examples of the new solutions spaces include development of zero waste economies, closed loop design for material re-use and making urban sustainable living easier.

Since launching the report, the WBCSD Secretariat has deployed insights from the Vision 2050 Initiative in its advocacy in the run up to Rio+20. Some of the individual member companies of the WBCSD have also used the Vision 2050 materials developed in the process to inform their own strategic planning processes. The WBCSD is also encouraging its 60 Regional Network partners to progress customized versions of Vision 2050. Translation of the Vision into local actions will not only clarify implementation gaps but might also reveal new pathways.

As such the WBCSD Vision 2050 highlights challenges of relating different methods, linking to other processes, engaging diverse actors and broadening perspectives to include the local scale. The combination of scenarios and visioning also enabled a much deeper reframing of the current situation in that some milestones highlight the need to rethink the conventional economic model of consumption-led growth.

These cases describe how plausible scenarios have helped grapple with the evolutionary potential of a more complex world. By engaging different perspectives and providing a set of interpretive frames, plausibility based scenarios have revealed the implausibility of assumptions underpinning the dominant narrative of linear change and continuous growth.

The WBCSD case highlights the role of intuitive logics scenarios can not only help appreciate the evolutionary potential of a more complex world but also help galvanize momentum towards making the future by deploying plausible scenarios with modeling, as part of a visioning and backcasting process.

4. Discussion and conclusions

In this paper we focus on the tradition of the intuitive logics school of scenarios to demonstrate the value of plausibility-based scenarios as an on-ramp to complexity thinking.

We offer insights based on a selection of practical cases and through a review of relevant literature and a comparison of deeper, intellectual foundations.

We introduce a new typology that we suggest is helpful in explaining how intuitive logics scenario practices harnesses plausible, alternative futures to navigate complexity. It does so by attending to deeper, otherwise left implicit, assumptions about continuous and linear patterns of development.

Through different cases we show that the intuitive logics tradition in scenario practices is deployed in both organizational and inter-organizational settings to engage a diversity of perspectives, relevant to the different scales and interests that characterize complex systems. We also note that the intention for deploying plausibility-based scenarios varies between adapting to predetermined changes and making the future and navigating transitions.

These cases highlight five challenges that are shaping the further evolution in intuitive logics scenario practices;

- *Linking:* The value of any form of foresight is realized in its use. The output of scenario building in the intuitive logics tradition is recognized as also being an input to other processes, such as strategy, innovation and transition management. This raises the challenge of designing scenarios so they are fit for use and users i.e. the wider purpose of the intervention and, in turn, clarifying how and when to link with other processes. For example, scenario work is increasingly used to bridge to science and policy for purposes of deepening understanding of climate change and other grand challenges, but the linking is still seen as unsatisfactory, as indicated by suggestions for a further evolution in the next generation of IPCC scenarios. In the case of the WBCSD Vision 2050 Initiative, the linking was achieved via an intermediary product of pathways and milestones, rather than directly via the scenario building process. Harnessing scenarios as an 'on ramp' to complexity and linking scenarios to other processes, we suggest, offers an effective way of engaging policy and decision makers, thus avoiding the ivory tower confinement of complexity science. We suggest this is a rich vein for further research.
- *Deeper reframing:* Intuitive logics scenarios, with their explicit consideration of uncertainties and multiple perspectives, have always played a role in revealing and challenging conventional wisdom, in particular exposing the fallibility of assumptions of linear and exponential growth or 'business-as-usual'. In providing an 'on-ramp' to complexity, the plausibility-based Oxford (Growth and Health) scenarios have helped confront conventional economic wisdom rooted in assumptions of equilibrium, linearity and exponential growth and promoted an appreciation of the dynamic and multi-equilibrium nature of complex socio-economic systems. In the context of today's grand challenges, we suggest scenarios in the intuitive logics tradition provide a means to

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avoid conceptual crises and navigate alternative paradigms from neoclassical and complexity economics. At the same time, we note that in complexity-orientated futures practices e.g. proponents of an evolutionary paradigm in futures, of transition theory, etc. there is a suggestion of 'normative scenarios'. We suggest this confusion of plausible scenarios and a normative future should be resisted, else the contribution of the intuitive logics tradition to exposing uncomfortable knowledge and helping think the unthinkable will be lost. We encourage, instead, a role for plausibility-based scenarios, as a means to frame and reframe the dynamics of complex, puzzling and messy situations, in combination with visioning as a means to rethink the model of progress and purposefulness of human interventions. Questions for research include: When and how is plausibility about change in complex systems established: on what basis and by who is the plausibility of uncertain future developments acknowledged? Is there a role for Bayesian probability in scenarios aimed at harnessing plausibility to reframe the present rather than forecast the future?

- *Relating:* The WBCSD Vision 2050 Initiative shows that scenarios are being combined with other methods, such as quantitative modeling, visioning and horizon scanning. This raises a question about which methods to choose and how to sequence them for effectiveness in the context of the purpose of the intervention. Intuitive logics scenarios are increasing combined with quantitative modeling and suggestions for how to more effectively bridge modelers and stakeholders are in evidence, e.g. suggestions to use semi-quantitative methods such as Fuzzy Cognitive Maps. The availability of new complexity models and tools e.g. Agent-Based Models, and the prospect of combining these with plausible scenarios with agent-based models is another area ripe for research and reflexive practice.
- *Broadening:* all scenario work is focused e.g. a set of scenarios is relevant to a specific time horizon and a limited number of dimensions and drivers of change. In grappling with complex challenges, such as strategic renewal, organizational resilience, global sustainability and climate change, attention to cross-scale linkages and dynamics can be enabled by developing multiple sets of scenarios. This raises the question of how to ensure coherence and consistency across multiple sets of scenarios. There is a burgeoning literature on multi-scale scenarios contrasting perspectives between practitioners advocating quantitative methods (e.g. upscaling, downscaling) with others proposing alternative ways to ensure cross scale consistency and coherence. We suggest that insights from complexity on how to relate key assumptions on stylized facts or empirical evidence at a system-level to variables at intermediate levels will help to interpret and build coherence, clarifying the storylines of multi-scale scenarios. However, questions of how to relate qualitative and quantitative methods, e.g. sequence models and scenarios, remain open.
- *Engaging:* In recognition of the heterogeneity of agents in complex systems, of their worldviews, values, expectations and desires about the future, the challenge of enabling more effective and wider participation in progressing interdisciplinary and more holistic foresight practices is, in turn, shaping scenario practices in the intuitive logics tradition. We suggest insights from complexity pose three new questions for scenario practitioners: Who can help appreciate the dynamics of the system? Who can reset the model of progress? Who can intervene effectively in the system? For example, von Korff [81] suggests four categories of reasons for undertaking participation can be discerned: normative, instrumental, substantive and social learning. Harnessing plausibility-based scenarios in interventions aimed at seeing or seeding the future in the context of complex changes and challenges opens choices about the mode of stakeholder engagement [81:15] and the reasons for undertaking participation [82].

In conclusion, we suggest that scenarios provide an 'on-ramp' for accelerating the penetration of complexity thinking beyond its current reach within academe. We note that complex system perspectives are already being incorporated into scenario work and, as this paper identifies, point to critical shortcomings of the one-off, deductive building process.

We also highlight that in the development of complexity models, choices about picking a boundary of intrinsically open systems must be made and carry implications for notion of client and engagement of wider stakeholders and that these, in turn, are the starting point for initiative logics scenario work. Harnessing complexity thinking in combination with plausible scenarios, which function as framing and reframing devices to more systematically reveal and ground these choices, would be an improvement.

In the current state of the art study of complex systems, quantitative descriptions are limited to a relatively limited set of problems. We suggest that scenario work enables attention to cross scale linkages in a way that harnesses both individual and collective intuition sensitized to the dynamics of complex systems and their emergent characteristics, and could be an effective way of enhancing the study of more elaborate systems.

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