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RESEARCH ARTICLE

N-Factorial Scenarios: A Systems-Theoretical Approach to Scenario-Planning

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ABSTRACT

Scenarios are among the most popular techniques for managing the uncertainty and complexity of the future. Even the more sophisticated scenario designs, however, often reduce the future to a narrow set of typically only two key factors that are arranged into a four-square matrix representing four distinct yet interrelated scenarios. Consequently, scenarios have been criticised for being simplistic or reductionist by design. In this article, we address these criticisms by proposing a basic design for n-factorial scenarios. Following a short discussion of the procedures and limitations of classical scenario design, we draw on the example of a standard 2×2 matrix titled 'Four Scenarios for the Digital Transformation' to illustrate the limitations of the standard approach and demonstrate the potential of a digital approach to scenario building. We conclude that standard scenario planning is often characterised by a systematic omission of potentially critical scenarios, which our proposed digital approach can detect and map out.

1 | Introduction

Since the early days of foresight and futures studies, scenarios have remained among the most popular techniques used by organisations to manage the uncertainty and complexity of the future. Scenario planning has constantly ranked among the 25 most frequently used management tools in the Bain & Company Tools & Trends Survey for over two decades now. Major corporations, NGOs and global institutions have been employing scenarios for more than half a century to address a wide variety of issues such as market changes, demographic challenges, climate change, space colonisation, or the coronavirus crisis (Campa, Szocik, and Braddock 2019; Esfeld 2022; Kaivo-oja 1999; Kaivo-oja, Luukkanen, and Malaska 2001; Kuhbandner et al. 2022; Samanaseh et al. 2023; Serrano et al. 2018; Taagepera 2014; Tegegne, Penker, and Wurzinger 2016; Wicke et al. 2022; Wójtowicz and Szocik 2021).

The origins and evolution of scenario techniques in long-range business planning have been well-documented, highlighting their transformation from predictive tools to instruments for navigating complexity (Bradfield et al. 2005). Scenarios 'are not predictions, but plausible stories about how the future could evolve in uncertain and often surprising ways' (MacKay and Stoyanova 2017, 89), and unlike conventional planning that follows a 'predict and control' strategy (Ramírez and Wilkinson 2016), scenario planning does not externalise uncertainties, but supports their internalisation in the form of informed judgements about an uncertain and uncontrollable future (van der Heijden 1996; Wack 1985a, 1985b). This internalisation is achieved by scenario analyses that split the future into typically 3–6 distinct yet inter-related futures (Amer, Daim, and Jetter 2013, 33). Within the larger context of scenario planning, the ultimate purpose of 'the scenario and the scenario system is not to produce scenarios, the purpose is option creation, is to generate new options that you would not have thought

of otherwise' (Wack 1982 in Chermack and Coons 2015, 191). This concept of scenarios aligns with Godet's (1994) notion of scenarios as 'future memories', which constitute not merely reflections on possible futures but rather frameworks for strategic decision-making.

Over the decades, the pertinent literature has focused on definitions, use cases, selection criteria, ideal arrangements, or enhancements of scenarios (Derbyshire and Wright 2017; Wright and Goodwin 2009; Wright et al. 2017). Yet, while there is some evidence for positive impacts of scenario planning on organisational resilience (Bodin, Chermack, and Coons 2016; Bouhalleb and Tapinos 2023; Chermack and Nimon 2008; Chermack et al. 2020; Hillmann et al. 2018; Marinković et al. 2022), this evidence has at times been qualified as scarce (Wright et al. 2017; Bouhalleb and Smida 2018). This observation blends into the contention that the bulk of research on scenarios is application-focused, descriptive, and thus still under-developed particularly regarding theory development (Derbyshire 2017; Meadows and O'Brien 2020; Spaniol and Rowland 2018). Moreover, as Durance and Godet (2010) caution, scenario-building processes can sometimes be misapplied, with a tendency towards overly simplified approaches that undermine the tool's potential for nuanced foresight.

Recent calls for deeper theoretical and empirical examinations of the role of scenarios in organisational contexts have led to emerging research programs that focus less on the ascribed qualities of scenarios and more on how actors collectively apply or cocreate them (Andersson and Westholm 2019; Rowland and Spaniol 2017; Wouters, De Fraine, and Simons 2019; Wenzel et al. 2020; Garsten and Sörbom 2021). This focus on collective scenario practice or action, however, seems to contradict the original purpose of scenario planning. According to Chermack & Coons (2015, 192), it is a recent development that 'scenario planning tends to be a group process in which many have equal input. As a result, it can be an exercise in regression toward the mean, generating little that is novel or provocative'. This suggests a considerable risk that scholars focused on group interactions and negotiations around scenarios may actually be studying and coperforming a process by which 'modern scenario planning has been watered down' (id., 191), rather than studying the forms and impacts of the tool in question.

A second line of criticism, however, has focused on the tool itself. The contention here is not only that the tool has increasingly been presented 'relatively straightforward and linear' and thus 'the scenario process has become a somewhat simplistic, off-the-shelf tool' (Derbyshire and Wright 2017, 262), but also that scenarios are reductionist by design (Martineau 2017). Despite occasional excursions into three-dimensional modelling (e.g., Mendonça et al. 2009), and even rarer attempts at n-factorial scenarios (Ritchey 2018), the standard approach of scenario-building indeed remains the compilation of a list of uncertain factors, out of which only the two most important are selected to create the famous four quadrants matrix and thus up to four scenarios (Amer, Daim, and Jetter 2013; Ramirez and Wilkinson 2014). Even more sophisticated designs, such as the Wilson matrix, ultimately resort to plotting a larger number of factors on a 2×2 impact-versus-probability-matrix, thus limiting the interaction between the factors as well as their potential to create interrelated scenarios.

In the present article, we aim to address the second line of criticism by introducing a basic design for n-factorial scenarios. Our method of creating scenario frames addresses some of the issues inherent in the 2×2 model, while also complementing traditional approaches to scenario design. After briefly discussing the procedures and limitations of classical scenario design, we shall draw on the example of a standard 2×2 matrix, 'Four Scenarios for the Digital Transformation', developed by Bodrožić and Adler (2022) to illustrate these limitations and demonstrate the potential of a truly digital approach to scenario building. The results of this demonstration suggest that standard scenario planning is characterised by a systematic omission of potentially critical scenarios, which can be identified and charted by our proposed digital approach. In thus replacing analogue 'sliding scale' models underlying most future scenarios, including those popularised by foundational work from Stafford Beer or Buckminster Fuller, our method represents truly digitally transformed approach to scenario planning.

2 | Standard Scenario Planning: Two-Dimensional Limits to Growth

Brief histories of scenario planning date its origins back to transition from World War II to the Cold War (Derbyshire 2017; MacKay and Stoyanova 2017; Rowland and Spaniol 2017). However, early traces of scenario thinking have been identified across a broad historical and geographical range of contexts. These span from Mesopotamian 'celestial sciences' and the role of 'foreknowledge' in Sun Tzu's *The Art of War*, to Prussian military wargaming exercises, while the 'term 'scenario' itself harkens back to the silent film era, when a film script was called a scenario because of its creative, literary and playful connotations' (MacKay and McKiernan 2018). This association with creativity, narration, and playfulness, along with the resulting potential for surprise, may still be considered constitutive of scenario planning (Derbyshire 2017) and resonates with its deeper historical roots in theological and philosophical traditions of computational thought, which sought to model and understand complex systems of possible futures (Williams 2016).

Scenarios gained a first peak of popularity with the publication of *The Limits to growth* (Meadows et al. 1972), while Shell is credited as the first private sector organisation to have applied scenario planning, particularly during the 1970s oil crises (Ringland 2002). Williams (2016) identifies this emergence of scenario planning as part of a broader cultural shift towards observations of 'World Futures', where the objective was not just prediction but the systematic explorations of multiple, plausible futures. This transition underscored a pluralistic and narrative-driven approach that has influenced how scenarios are conceptualised today, at a time when 'scenario planning (...) has progressed beyond fashion' (McKiernan 2017, 66).

Based on a literature review of pertinent 77 definitions, Spaniol and Rowland (2019) conclude that scenarios may be

defined as systematised sets of comparatively different future-oriented narrative descriptions of possible and plausible events or situations that might occur in an external context. This meta-definition is compatible with the idea that, 'in an organisational context, scenario planning is a strategic planning process that attempts to explore alternative states of being, separated from the present by some temporal movement and from each other alternative by a turn in logic or reasoning' (Fuller 2017, p.).

The standard approach to producing scenarios is outlined in Wright and Cairns' (2011, 22) listed description of the 'The scenario process in action':

- Stage 1: *Setting the Agenda*—defining the issue and process, and setting the scenario timescale
- Stage 2: *Determining the Driving Forces*—working, first, individually, and then as a group
- Stage 3: *Clustering the Driving Forces*—group discussion to develop, test and name the clusters
- Stage 4: *Defining the Cluster Outcomes*—defining two extreme, but yet highly plausible—and hence, possible—outcomes for each of the clusters over the scenario timescale
- Stage 5: *Impact/Uncertainty Matrix*—determining the key scenario factors, A and B
- Stage 6: *Framing the Scenarios*—defining the extreme outcomes of the key factors, A1/A2 and B1/B2
- Stage 7: *Scoping the Scenarios*—building the set of broad descriptors for four scenarios
- Stage 8: *Developing the Scenarios*—working in sub-groups to develop scenario storylines, including key events, their chronological structure, and the 'who and why' of what happens'.

Though this process clearly combines what Amer et al. (2013, 34) refer to as minimal and standard approaches for drafting scenarios, the outcome of this exercise ultimately boils down to the result of the minimal approach, namely, a four quadrant or 2×2 matrix containing or framing four scenarios. Figure 1 depicts the critical phase of the process:

Figure 1 shows a set of pre-selected factors, which had already been ranked along the horizontal axis based on their assumed impact on the future course of the issue at stake. These factors have now further been ranked according to their degree of uncertainty. As a result, we find that factors A and B have been identified as the two most impactful and uncertain factors in the entire set, and it is typically these two factors that the final four-square matrix depicted in Figure 2 is made of.

Figure 2 shows a matrix created by the combination of the two high-impact and high-uncertainty factors, A and B. In this figure, the grey boxes or post-its, respectively, do not refer to (sub-) factors anymore, but rather to descriptors that help to flesh out the four scenarios created by different combinations of factors A and B. The numbers behind the letters

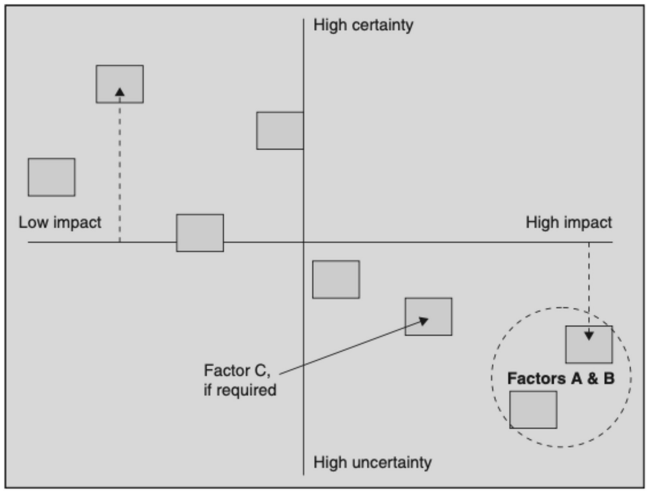

FIGURE 1 | Impact/uncertainty matrix: relative certainty/uncertainty of outcomes (Wright and Cairns, 2011, 38).

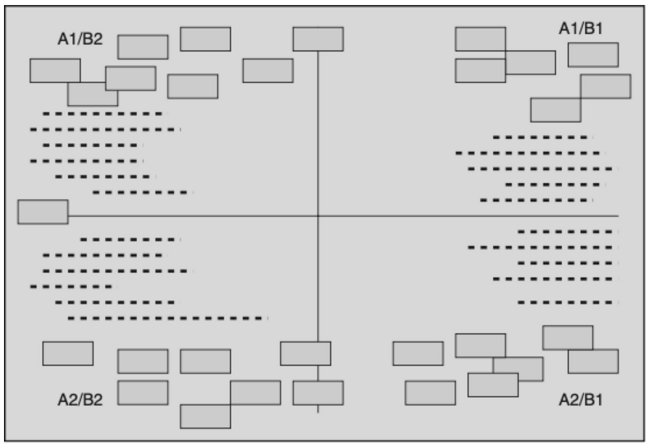

FIGURE 2 | Framing and scoping the scenarios (Wright and Cairns, 2011, 42).

indicate that A and B are almost always conceived as continua between the poles of A1 and A2 and B1 and B2, respectively. The above examples of certainty versus uncertainty and impact versus insignificance are cases in point. The fact that we are facing a more/less- or better/worse rather than either/or-logic is further illustrated by the circumstance that some descriptors in Figure 2 have been posted onto rather than next to the dividing lines between the scenarios. According to Chermack (2022), there has been a general trend towards designing scenario frameworks using continuums rather than clear-cut distinctions. At the end, we are looking at a window to a world made of four different futures, in which there is little of both A and B (A2/B2), much of both A and B (A1/A2), and two mixed scenarios.

In revisiting Figure 1, we notice an arrow pointing at a factor C that might deserve our attention, 'if required'. The case of this factor is interesting insofar as it raises the question of how it might be integrated into the scenario depicted in Figure 2, if required. The answer, however, is as brief and tacit as it is disappointing. Factor C is just a 'Plan B':

> If one or more of the four combinations is viewed by the scenario team as implausible, then Factors A and B are not independent of one another. At this point, Factors A and B could be combined as one factor and another possible factor, Factor C, should be selected as a potential second factor from the previously developed impact/predictability matrix.
>
> (Wright and Cairns, 2011, 39)

The key message is that factor C might replace one of the two other factors, 'if required'. A systematic integration of third, fourth, or further factors into the ultimate scenario design is not foreseen. This issue is typical of most scenario design processes and not resolved if, like in the case of Wilson matrices, the middle-ranges between the poles are designated as 'medium' categories. Thus, the inclusion and adequate representation of more-than-two-factorial scenarios remains an issue.

3 | Digital Transformation of Scenario-Building: From False to True Distinctions

The main contention of this article is that the above limits to multifactorial scenario-building are a result of the intentional or unintentional use of false distinctions in scenario design. Once this issue is addressed, these limits can be overcome.

> True distinctions are made of two mutually exclusive and jointly exhaustive sides (...). True distinctions spilt the entire space in which they are drawn into two sides and thus create a world where everything located in it belongs exclusively to either the one or the other side. Distinctions that fail to satisfy this definition may consequently be defined as false distinctions.
>
> (Roth 2023a, 452)

Whereas true distinctions split the entire frame of reference, false distinctions fail to do so. As a result, architectures made of true distinctions create different 'windows to the world' than architectures of false distinctions. This circumstance can be illustrated by a brief discussion of Table 1.

As is well known, the famous SWOT matrix reproduced in Table 1 is created by a cross-tabling of two distinctions. These distinctions are *positive* versus *negative* and, depending on the source, *internal* versus *external* (Weihrich 1982) or *present* versus *future* (Humphrey 2005). In looking at Table 1, it is obvious that the utility of the resulting window to the world critically depends on whether this window is made of true or false distinctions. Whereas the distinctions positive/negative and internal/external constitute reasonably true distinctions, the distinction between present and future is clearly not jointly exhaustive unless we completely ignore the past. Thus, we find that combinations of true distinctions create universal (though not exclusive) windows to the world, whereas windows made of false distinctions are of limited utility. Moreover, it is obvious that the tool is most useful if distinctions such as positive/negative actually are treated as mutually exclusive categories rather than as two poles of one continuum.

TABLE 1 | SWOT as an architecture of distinctions (author provided).

	Positive	Negative
Internal *Present*	Strength	Weakness
External *Future*	Opportunity	Threat

If we contrast these considerations with the daily routine of scenario-making, however, it becomes evident that scenarios made of false distinctions are prevalent. Consider the four scenarios for the digital transformation identified by Bodrožić and Adler (2022) and depicted in Figure 3, for example.

In looking at Figure 3, we find that the most frequent terms are 'of', 'digital', and 'dominance'. Whereas the second term acts as topic marker, the third term clearly indicates that we are looking at a traditional window made of two continua. Both 'Business Process management' versus 'Community-and-Collaboration management' and 'proactive system-building public policy' versus 'neoliberal laissez-faire public policy', therefore, indicate poles of their respective continuum. As everything on this map seems to be a matter of gradual transitions, it is safe to say that this map is not made of mutually exclusive concepts and thus based on false distinctions. But even if we treated 'proactive' versus 'neoliberal' public policy as mutually exclusive categories, the question remained as to whether these concepts are jointly exhaustive. This, however, is not the case as Bodrožić & Adler (2022, 117) claim that *the* 'alternative to a neoliberal laissez-faire regime' is the 'new form of system-building regime' described by Mazzucato (2015, 2021) in terms of her idea of an 'entrepreneurial state' that takes the lead and defines the economic missions of a 'mission economy', while Mazzucato (2020, 59) is very clear that her idea of a mission economy 'is not about socialism', but rather about an alternative between laissez-faire capitalism and a socialist command economy. The vertical axis in Figure 3, therefore, represents only a smaller section of a larger continuum

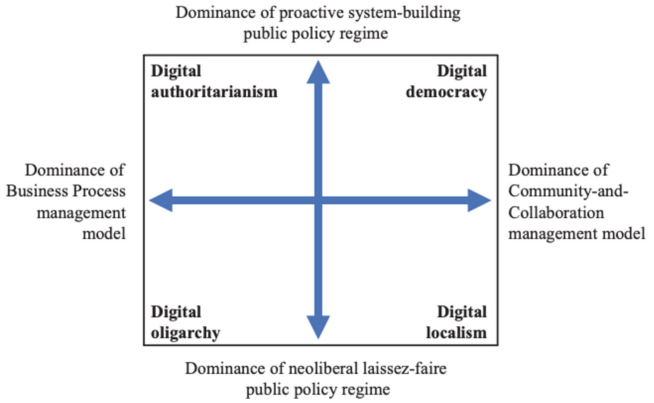

FIGURE 3 | Four scenarios for the digital transformation (Bodrožić and Adler 2022, 120). [Colour figure can be viewed at wileyonlinelibrary.com]

between capitalist laissez-faire and socialist central planning regimes.

Even in looking at the larger continuum between capitalist and socialist regimes, however, we remain confronted with the question whether capitalism/socialism is a true distinction. This question is critical as, true to Roth (2019, 2023a, 2023b), true distinctions can be safely combined, whereas false distinctions ought to be translated into two true ones. Tables 2 and 3 illustrate the issues at stake.

If we take capitalism/socialism for a true distinction, we can combine it with other distinctions, including the distinction itself. The result of such a self-application is shown in Table 2 and makes a strong case that capitalism/socialism is a false distinction, at least unless we suggest that capitalist socialisms and socialist capitalisms are independent categories rather than middle-grounds or mixed types.

The cross-check in Table 3, too, indicates that capitalism/socialism is a false distinction. In translating this false distinction into two true ones, capitalism/noncapitalism and socialism/nonsocialism, we find that both capitalism and socialism are only two out of a much larger set of regimes.

Considering this discussion, it is reasonable to infer that the scenarios identified by Bodrožić and Adler (2022) emerge through an architecture of distinctions that are neither mutually exclusive nor jointly exhaustive and, thus, false distinctions. This, in turn, suggests that the authors present a forced focus on a narrow quadrant rather than a full window to the futures of digital transformation, while the circumstance that they apply analogue, gradual thinking to their digital topic adds another layer of concern. As argued in the precedent chapter, however, the prevalence of gradual thinking and false distinctions is not specific to the authors' approach but is characteristic of the entire craft of scenario-building.

TABLE 2 | Capitalism/socialism. A true distinction? (Roth 2023a, 455).

	Capitalism	**Socialism**
Capitalism	Capitalism	Socialist capitalism
Socialism	Capitalist socialism	Socialism

The primary takeaway from the above discussion is then the realisation that when examining a typical 2×2 scenario matrix, we are actually faced with a much larger number of distinctions. In the case of Figure 3, these distinctions are non-/proactive, non-/laissez-faire, non-/business process management, and non-/collaborative management. Add to this a total of four more/less distinctions. As we shall demonstrate in the subsequent chapter, this multitude of distinctions suggests that we are dealing with more scenarios than actually displayed in such a typical four-square matrix.

4 | N-Factorial Scenarios

Even if we abstract from the more/less distinctions as well as from the implicit distinction between digital transformation and no digital transformation, the unfolding of the scenario map presented in Figure 3 leads to a larger number of scenarios than initially displayed on it. Table 4 presents one way to map the resulting complexity.

Table 4 presents a digitally coded version of the fully unfolded scenario map presented in Figure 3. As it becomes apparent, the scenarios highlighted in Figure 3 represent only a proportion of all scenarios actually contained by it. In fact, the scenarios 'digital authoritarianism', 'digital democracy', digital oligarchy' and 'digital localism' identified by Bodrožić and Adler's (2022) correspond to the four highlighted scenarios 7, 6, 11 and 10, respectively. Whereas it is understandable that scenario designers tacitly exclude scenario 1, that is the irrelevance of all identified factors (scenario 1), it is less reasonable to negate situations where all factors or dimensions are 'dominant' or given (scenario 16). In the present example, this would be the case of a scenario where an entrepreneurial state competes with other entrepreneurial actors in a laissez-faire economy characterised by both business process management and collaboration management, that is, by 'collaborative business process management' models (Niehaves and Plattfaut 2011). On all accounts, the uncommented omission of 75% of the scenarios identified in Table 4 is justified only in scenarios maps that are made of true distinctions, which is clearly not the case in Figure 3.

On a positive note, one major aspect of the above digital transformation of scenario mapping and design is that this approach is not limited to the traditional number of two key factors *if and only if* these key factors refer to, or can be translated into, true distinctions (see Table 5).

TABLE 3 | Capitalism/socialism. A false distinction (slightly modified from Roth 2023a, 455).

	Capitalism	**Noncapitalism**
Socialism	Capitalist socialism Socialist capitalism	Socialism
Nonsocialism	Capitalism	Despotism Feudalism Fascism Environmentalism etc.

TABLE 4 | Figure 3, unfolded (author provided).

	Laissez-faire	Proactive	Business process	Collaborative
Scenario 1	0	0	0	0
Scenario 2	0	0	0	1
Scenario 3	0	0	1	0
Scenario 4	0	0	1	1
Scenario 5	0	1	0	0
Scenario 6	0	1	0	1
Scenario 7	0	1	1	0
Scenario 8	0	1	1	1
Scenario 9	1	0	0	0
Scenario 10	1	0	0	1
Scenario 11	1	0	1	0
Scenario 12	1	0	1	1
Scenario 13	1	1	0	0
Scenario 14	1	1	0	1
Scenario 15	1	1	1	0
Scenario 16	1	1	1	1

TABLE 5 | N-factorial scenario mapping: a digital approach (author provided).

	Factor …	Factor 3	Factor 2	Factor 1	Description
Scenario 0	…	0	0	0	…
Scenario 1	…	0	0	1	…
Scenario 2	…	0	1	0	…
Scenario 3	…	0	1	1	…
Scenario 4	…	1	0	0	…
Scenario 5	…	1	0	1	…
Scenario 6	…	1	1	0	…
Scenario 7	…	1	1	1	…
…	…	…	…	…	…

In looking at Table 5, we find that a digital approach to scenario mapping and design does, in a first step, not necessarily require the use of electronic computers. In fact, arrangements of the size and complexity of Tables 4 and 5 are most likely manageable for most human computers. What is interesting and critical about Table 5, however, is the existence of what has been relabelled as 'Scenario 0', that is the case where none of the identified key factors plays a key role in shaping the future. These 'null scenarios' might therefore act as constant reminders of the speculative nature of scenario mapping and design and, thus, as remote functional equivalents of the null hypotheses in quantitative research methodologies. Another critical aspect of the present digital approach is that it prevents the omission of implicit scenarios and puts an additional focus on the process of the pre-selection of those scenarios that are developed in greater details at later stages of the scenario planning process. Thus, the proposed approach is instrumental for both the development of original n-factorial scenarios and for the examination and 'unfolding' of traditional four-square matrix scenarios.

5 | Conclusions

Scenarios remain among the most important tools for managing the future. Yet, even more sophisticated scenario designs tend to funnel down the future to a narrow set of key factors, which are either plotted on a 2×2 matrix or used to create a world of four different yet interrelated scenarios of the future. Consequently,

scenarios have been criticised as being simplistic or reductionist by design.

This article addresses this criticism by proposing a basic framework for n-factorial scenario design. We drew on the exemplary 2×2 matrix of 'Four Scenarios for the Digital Transformation' developed by Bodrožić and Adler (2022) to demonstrate that standard approaches to scenario building are characterised by a systematic omission of potentially critical scenarios. Our proposed digital approach can detect and map out these overlooked scenarios. Among these scenarios, we highlighted the importance of a 'null scenario' in which none of the identified critical factors play a key role in shaping the future.

As indicated by Tables 4 and 5, our approach to scenario planning implies translations of analogue, gradual factors into digital, binary ones. As a result of this exercise, it becomes apparent that, unlike earlier attempts at tabular representations of scenarios (e.g., Kaivo-Oja 2013), our *integrated and binary* scenario mapping approach does not impose a limit on the number of factors that may be considered. Whereas it is evident that larger numbers of factors might eventually necessitate computer supported-supported scenario selection practices as outlined by Amer, Jetter, and Daim (2011); Amer, Daim, and Jetter (2013), our approach expands the range and number of factors that human scenario planners can consider. Analyses of 3×3 or 4×4 matrices, such as those presented in Tables 4 and 5, are certainly not beyond the capacities of most human computer.

Though our approach is distinctly digital, it is also grounded on a theoretical framework that allows for the translation of analogue into digital factors or distinctions. Thus, our introduction to the distinction between true and false distinctions provides a theoretical interface between the still rather analogue world of scenario design and planning on the one hand, and computerised approaches to scenario selection and cross-impact analysis (Amer, Jetter, and Daim 2011) on the other hand, the latter of which have remained black-boxes to many scenario-planners so far. As our approach is connected to a larger research programme towards a digital transformation of social theory (Roth 2019), it also contributes to theory-development in the still under-theorised domain of scenario planning and design (Derbyshire 2017; Meadows and O'Brien 2020; Spaniol and Rowland 2018).

Whereas we strongly advocate the inclusion of more than two key factors into scenario design processes, we primarily recommend our approach for cases where traditional 2×2 matrices appear to provide overly reductionist views of the future. In all other instances, a 2×2 matrix will certainly suffice and create 'complete and coherent scenarios' (Godet 2010, 17) *if* it is made of true distinctions.

Ethics Statement

The authors have nothing to report.

Data Availability Statement

The authors have nothing to report.

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