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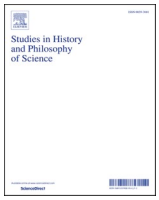

Revisiting the social contract for science

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ABSTRACT

The conceptual framework that presents scientific researchers in a transactional relationship with wider society, receiving funding and autonomy in exchange for producing beneficial discoveries and outcomes, is generally known as the social contract for science. This contract has been revisited multiple times, with iterations evolving as 'wicked problems' have become identified by many as priorities for research, and as funding models have become more generally tied to predefined or applied outcomes. In parallel, within the Arts and Humanities, there has been growing discourse on the characteristics and ramifications of 'Modernism', 'Postmodernism', 'Liquid Modernity', and 'Metamodernism'. This paper juxtaposes these two separate bodies of thought, and in doing so, identifies that both are underpinned by similar core themes: (1) 'trust' (including a loss of trust in professional researchers, or objective, unproblematic truth), (2) 'acceleration' (including acceleration of research outputs), and (3) 'crisis' (including narratives of risk, urgency, and emergency underpinning research). Comparison also reveals the importance of narrative, 'polylogue', and transparency in navigating modern research into 'meta-crises'. Considering the next iteration of the Social Contract for Science may be helpful in navigating uncertainty, complexity, and (in some quarters) dissatisfaction with the current funding model of university research.

1. Introduction

There are many ways in which professional researchers and wider society have complex, reciprocal, and dynamic interactions with each other (e.g. Erickson, 2016; Latour, 1987; Nowotny et al., 2001; Pickering, 1995); scientific research does not happen in a vacuum. In recent years researchers have been increasingly encouraged to consider the potential application or impact of their work (e.g. Kearnes & Wienroth, 2011; Martin, 2011; Smith et al., 2011; Sutton, 2020), to articulate how the research aligns with topics prioritised by the state (e.g. Demeritt, 2000; Gibbons et al., 1994), and to contribute to addressing the requirements of industry (e.g. Dowling, 2015; see also Thorpe & Gregory, 2010 on commercialisation). The study of the interactions between science, technology, and society has become increasingly formalised over time, demonstrated by the expanding field of 'Science and Technology Studies' (STS) (e.g. Sismondo, 2010), and the creation of new journals such as the Journal of Responsible Innovation, which consider the interactions of science, technology, and society (Guston et al., 2014). There is a growing discourse addressing explorations of scientific methodologies and cultures, with influential anthropologies of scientific practice (e.g. Hess, 2001; Latour, 1987; Latour & Woolgar, 1986), explorations of questions of philosophy, ontology, and epistemology (e.g. Woolgar & Lezaun, 2013), and examinations of real contexts where science, technology, and society intersect and interact. For example, studies may explore intersections where the friction of controversy emerges (e.g. Sismondo, 2010), where failures of communication or process have significant and lasting impacts (e.g. Lash et al., 1996; Wynne, 1992, 2013), or where models of public engagement or commercialisation (such as the deficit model and linear model) are traced and critiqued (e.g. Macnaghten, 2020; Thorpe & Gregory, 2010).

One concept that has influenced discussions of the relationship between science and society is the 'Social Contract for Science', a framework for describing the relationship between professional researchers and wider society (Brooks, 1987, 1993; Bush, 1945; Steelman, 1947). The Social Contract for Science expresses a transactional relationship between the two entities, whereby both parties have expectations for the conduct and treatment of the other: society provides scientific researchers with levels of funding and autonomy in exchange for the production of tangible benefits; in turn, society benefits from a stream of new discoveries and new products enabled by the generous levels of

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funding and autonomy conferred on scientific researchers (e.g. Bush, 1945; Guston, 2000; Lubchenco, 1998). In this paper, we examine how the Social Contract for Science has been revisited and reinvented over the years, with different addenda or shifts in emphasis proposed over time (e.g. Blue & Davidson, 2020; Guston, 2000; Lubchenco, 1998). Given the connection between science and the societal framing of science, we suggest here that there is value in considering the impacts of these reinventions of the Social Contract for Science alongside the context of different schools of philosophical thought, which also frame the value and practice of research.

At the same time as the rounds of reinvention of the imagined contract between science and society, scholars positioned more within Arts and Humanities disciplines have presented successive waves of philosophical thinking, some of which emerged as schools known as 'Modernism' (see, e.g. Pipere & Mārtinsone, 2022), 'Post-Modernism' (see, e.g. Bauman, 1992; Bertens, 1995), and more recently 'Reflexive' (e.g. Beck, 1992a; Beck et al., 1994; Giddens, 1991) or 'Liquid' Modernity (e.g. Bauman, 2000, 2005, 2007), and 'Metamodernism' (Pipere & Mārtinsone, 2022). These explorations sit in parallel to the re-examinations of the Social Contract for Science, at their core grappling with the same questions of increasing complexity, uncertainty, and risk (e.g. Pipere and Martinson, 2022), increasing regulation and assessment of academic productivity (e.g. Ioannidis et al., 2018; Mattiazzi & Vila-Petroff, 2021), and an interrogation of the 'trust' which might be placed in a class of professional researchers (e.g. Foucault, 1970, 1975, 1977).

There is a growing discussion about the future of science and how it is perceived and valued by society in an era of 'metacrises' (Pipere & Mārtinsone, 2022). International bodies are considering the nature of science and the infrastructures within which science is conducted. For example, extensive work is being undertaken to address the impact of digitalisation (International Science Council, 2024), pressures on academic freedom (Scientific Foresight Unit European Parliamentary Research Service, 2023), and research assessment frameworks (COARA; DORA, 2024) to name a few. Concurrently, research institutions are seeing significant budget cuts (e.g. Babina et al., 2023; Hamilton & Nielsen, 2021; Mintz, 2021), specific disciplines are losing funding, especially within Arts and Humanities (e.g. Ashton, 2023; Moran, 2022; Tight, 2024), and there is a growing discussion about the sustainability of research and how it can be funded (Morgan, 2024). The central argument of this paper is that integrating and/or juxtaposing the two bodies of theory of the Social Contract for Science and the philosophical theories from within the Arts, Humanities, and Social Sciences can offer valuable insights to shed light on current tensions and contradictions in the discourse around the relationship between scientific research and wider society. Holding both bodies of theory simultaneously offers the potential to illuminate wider trends that frame the current context of science in society, and also creates the opportunity to actively consider what the next iteration of the Social Contract for Science could be that can best serve society now and in the future. It is the aim of this paper to adopt a broad, conceptual lens rather than a granular, historical lens. Accordingly, while this paper makes use of certain historical examples, the aim is not to conduct in-depth analysis of the causes and consequences of any one specific policy decision, or to elaborate on any one specific case study. Instead, the aim of this paper is to juxtapose these two bodies of theory, and to highlight the similarities, contrasts, and questions which arise when both are considered simultaneously.

1.1. A brief history of the social contract for science

'The Social Contract for Science' is a framework for describing the relationship between a class of professional researchers and wider society. The Social Contract encompasses a reciprocal relationship, with both parties having expectations for the conduct and treatment of the other.

1.1.1. The first iteration, in the 1940s and 1950s

The first writing on the topic of 'research contracts' emerged in the 1940s, with *The Endless Frontier* by Vannevar Bush (1945) and *Science and Public Policy* by John Steelman (1947) published in the USA and UK respectively. Both texts were produced in the shadow of World War Two, and emphasised how military scientific accomplishments, such as the mass-production of penicillin and implementation of radar (Bush, 1945), demonstrated the value of well-funded scientific research. Both texts articulated that science was useful in crises, and both expressed that it was important to maintain a certain reservoir of scientists in the same way that one might maintain a cavalry or an infantry (ibid.).

The idea at the heart of 'The Social Contract for Science' was that the scientific profession could be imagined to have a transactional relationship with society, where rewards such as autonomy, flexibility, funding, and security could be earned in return for providing tangible benefits (ibid.). Interestingly, this model presupposed that there was a separation between scientists and society and contributed to a narrative that professional researchers do not themselves belong to society (Gibbons, 1999). These early writings on scientific policy both acknowledged that the path from exploratory research to productive outputs could be circuitous. Both Bush and Steelman stressed the need for researchers to have the freedom to produce 'basic' research, where applications are not immediately apparent (Bush, 1945; Pielke, 2010; Steelman, 1947). Steelman illustrated this point with the example of the atomic bomb; the theoretical physics which underpinned its operation was not necessarily undertaken with a physical end product in mind (Steelman, 1947). Bush's *The Endless Frontier* (1945) contained recommendations for the creation of a national foundation to manage the allocation of funds for 'basic' research, and for training scientific personnel (Bush, 1945). It is worthy to note that the creation of the 'National Science Foundation' was preceded by five years of debate (see: Kleinman, 1995). Dimensions of this debate included whether the control and administration of the foundation should be scientific experts, or non-scientific (and non-expert), and whether the foundation should support basic and/or applied research, and/or social science, and whether co-ordination should have a strong or vague mandate (Kleinman, 1995).

1.1.2. The 1960s and 1970s

The context of scientific policy in the 1960s and 1970s was intertwined with the influence of the Cold War (e.g. Agar, 2008; Agar, 2019; Heymann, 2017). A number of wider developments also impacted both the public perception of science, and the relationship between professional scientists and society. It has been suggested that three 'waves' were created that led to significant and lasting changes (Agar, 2008):

1. There was a trend towards publicly visible disagreements between scientific researchers, with debates that might formerly have taken place behind closed doors (for example, within internal committees, or the pages of journals), being played out in publicly accessible forums (Agar, 2008). Examples included debates over the appropriateness of universities conducting classified military research (Agar, 2008), debates surrounding the safety of nuclear power (Balogh, 1991), and debates over the risks of bioaccumulation of DDT pesticides (Agar, 2008; Carson, 1962).
2. The 1960s saw the emergence of a number of social movements which positioned themselves in opposition to 'authority' and which exhibited a number of relationships with scientific researchers (Agar, 2008). Some researchers were seen as acceptable targets for criticism as they aligned themselves with the 'authority' which the social movements challenged (for example, the Campaign for Nuclear Disarmament (CND) organised marches which ended at Aldermaston, the UK's nuclear weapons laboratory, that was home to scientists working on the technologies (Agar, 2008)). Other scientific researchers were seen as allies of social movements, with scientist-activists supporting and shaping activists' demands (Agar,

2008), such as the urgent call to action in '*Silent Spring*' (Carson, 1962).
3. There was also a third wave that consisted of increasing "orientation towards the self, in diverse ways", and with diverse effects (Agar, 2008, p.596).

Considering how these changes impacted the perceived 'social contract' for scientific researchers, it is possible to suggest that there was a bifurcation, with an establishment narrative, and reactionary counter-narrative informed by social movements. From the establishment, there continued to be belief in the utility of generously investing in science for 'defense' purposes (Edgerton, 1996; see also Agar, 2019), and a continuation of the 'linear model' endured (Agar, 2019). However, internationally, there was debate as to the extent to which governments could or should direct scientific endeavours through co-ordinated policy (e.g. Henriques & Larédo, 2013), with the UK being one of the countries that did at that time implement a centralised scrutiny of research (Henriques & Larédo, 2013; see also Edgerton, 2019), to shape national science and technology policy towards nationally desirable outcomes (Edgerton, 2019). From the perspective of social and environmental justice movements, it was the role of society to participate in the visible and public debates over what research was acceptable or desirable, with many activists in opposition to the military and industrial *status quo* (see: Agar, 2008; Carson, 1962). In this vision of the social contract, the participation of wider society, and motivated activists within society, would ensure that the innovations, discoveries, and products would be in the interests of wider society.

1.1.3. Revisions at the turn of the millennium

Interest in the Social Contract for Science was renewed at the end of the twentieth century, with multiple authors describing the first iteration to be in need of 'retiring' (Guston, 2000, p. 32), or beginning 'to unravel' (Demeritt, 2000, p. 309). Critique was commonly framed around the idea of the need to respond to increasing levels of complexity; both in institutional arrangements (Gibbons, 1999), alongside a growing awareness that universities were being reframed using the argot of industry and the corporation (Demeritt, 2000; see also Berman, 2012, on the shift towards markets in neoliberalism), while separately, authors stressed that the challenges that professional researchers were to face were increasingly multifaceted and intractable (e.g. Lubchenco, 1998). Lubchenco suggested that the 'urgent and unprecedented' (1998, p.491) challenges rendered visible by, for example, a growing awareness of environmental changes, required a new way of conceptualising and prioritising scientific research. At the same time, there was an acknowledgment that the reputation of science had, to some extent, been tarnished in the preceding decades. The 1960s saw increasing awareness of the potentially adverse effects of scientific research, with the exploration of the impact of pesticides and agrochemicals upon insect populations had acted as a rallying call for the nascent Western environmental movement (Carson, 1962; Lutts, 1985; Lytle, 2007), while concerns over the safety of nuclear technologies had filtered into the public consciousness (Bowler, 2009). The realisation of the potentially adverse effects of scientific or technical advancements, as exemplified in the context of pesticides and nuclear radiation, had challenged one of the key (and tacit) tenets of the social contract for science – that research was assumed to bring improvements (see: Blue & Davidson, 2020; Bowler, 2009; Guston & Keniston, 1994; Krishna, 2014). Amidst a similar context of unease around genetically-modified organisms at the turn of the millennium (e.g. Demeritt, 2000; Gibbons, 1999; Krishna, 2014) authors articulated that in a reimagined iteration of the Social Contract, it would not be enough for scientists to produce tangible benefits; publicly-funded science must be socially-robust (Gibbons, 1999), mindful of complexity (ibid.), conducted with humility (Jasanoff, 2003), and of clearly demonstrable relevance to wider society (e.g. Guston & Keniston, 1994). In addition to this expansion of criteria, there was a simultaneous contraction of autonomy; publicly funded science was no longer assumed to be an appropriate endeavour to be regulated by trust. Instead, the bodies which funded research regulated it through monitoring and assessing the quality and quantity of outputs, in the context of "a growing chorus of voices that was demanding that science, like other publicly funded services, be made publicly accountable and prove its value for money" (Demeritt, 2000, p. 309).

1.1.4. Twenty first century reiteration

Lubchenco (1998) identified the need to revisit the Social Contract for Science at the turn of the millennium due to 'urgent and unprecedented' challenges. In a similar manner, authors in recent years have highlighted how new and emergent situations (for example, the Covid-19 global pandemic (Pelling et al., 2022) and accelerating climate change (Blue & Davidson, 2020)) provide a compelling rationale to revisit the terms of the Social Contract for Science again. The vocabulary used in commentary has been critical, with authors referring to the Social Contract for Science as 'frayed' (Hooke, 2015), and requiring 'reinvention' (Euroscientist, 2015). Invitations to reimagine the Social Contract for Science have stressed that professional researchers now have a wider range of obligations, suggesting that research should be not only demonstrably relevant, but should exhibit excellence (Sunkel, 2015), transparency (Lubchenco & Rapley, 2020), a focus on urgent problems (ibid.), findings that are 'actionable' and readily implemented (Arnott et al., 2020), and should incorporate an understanding of 'justice' (Blue & Davidson, 2020) – including fair demographic representation and an equitable distribution of resources (ibid.). This inflection towards 'justice' and 'equity' can be considered within the context of wider debates that addressed what constitutes 'responsible innovation', and beneficial intersections of technology and society (see: Guston et al., 2014; Glerup & Horst, 2014). This reconsideration of the social contract for science was framed against a backdrop of statements from multidisciplinary organisations. For example, the *AAAS Statement on Scientific Freedom and Responsibility*, published in 2017, argued that "[scientific] freedom is inextricably linked to […] responsibility […] the duty to conduct and apply science with integrity, in the interest of humanity, in a spirit of stewardship for the environment, and with respect for human rights"(see: Jarvis, 2017, p. 462), while the International Science Council's *A Contemporary Perspective on the Free and Responsible Practice of Science in the* 21st *Century* suggests, in a similar vein, that "emphasizing the interdependency of freedom and responsibility in science […] reflects an important shift in thinking between the 20th and 21st centuries" (International Science Council, 2021: 3). The degree of autonomy and flexibility attached to funding is further diminished in this latest iteration of the social contract for science, with a narrative of customer-contractor relationships between society and science being increasingly discussed (Sunkel, 2015, p. 554). This framing builds upon the assertion of Demeritt, that the "discourse of public accountability has sought to make accountability synonymous with cost-effectiveness, public needs with the demands of paying customers, and public relevance with wealth generation and the research needs of policy making" (Demeritt, 2000, p. 313). In stark contrast to the original iteration of the Social Contract for Science, there is little space for the undertaking of 'basic research'. Indeed, where the emphasis is placed on research that directly responds to urgent challenges, with readily implementable solutions (e.g. Arnott et al., 2020), and in an environment of chronic underfunding of universities (e.g. Storeng & Palmer, 2019), where value is often placed on commercial potential (Larsen, 2011), concerns have been raised that basic and exploratory research may not be valued or prioritised (ibid.) and that practitioners of basic research may receive lower levels of external funding (Bentley et al., 2015), when compared to applied research.

1.1.5. Changes over time

A summary of changes to the Social Contract for Science since the 1940s from an anglo-american perspective is provided in Fig. 1. Three

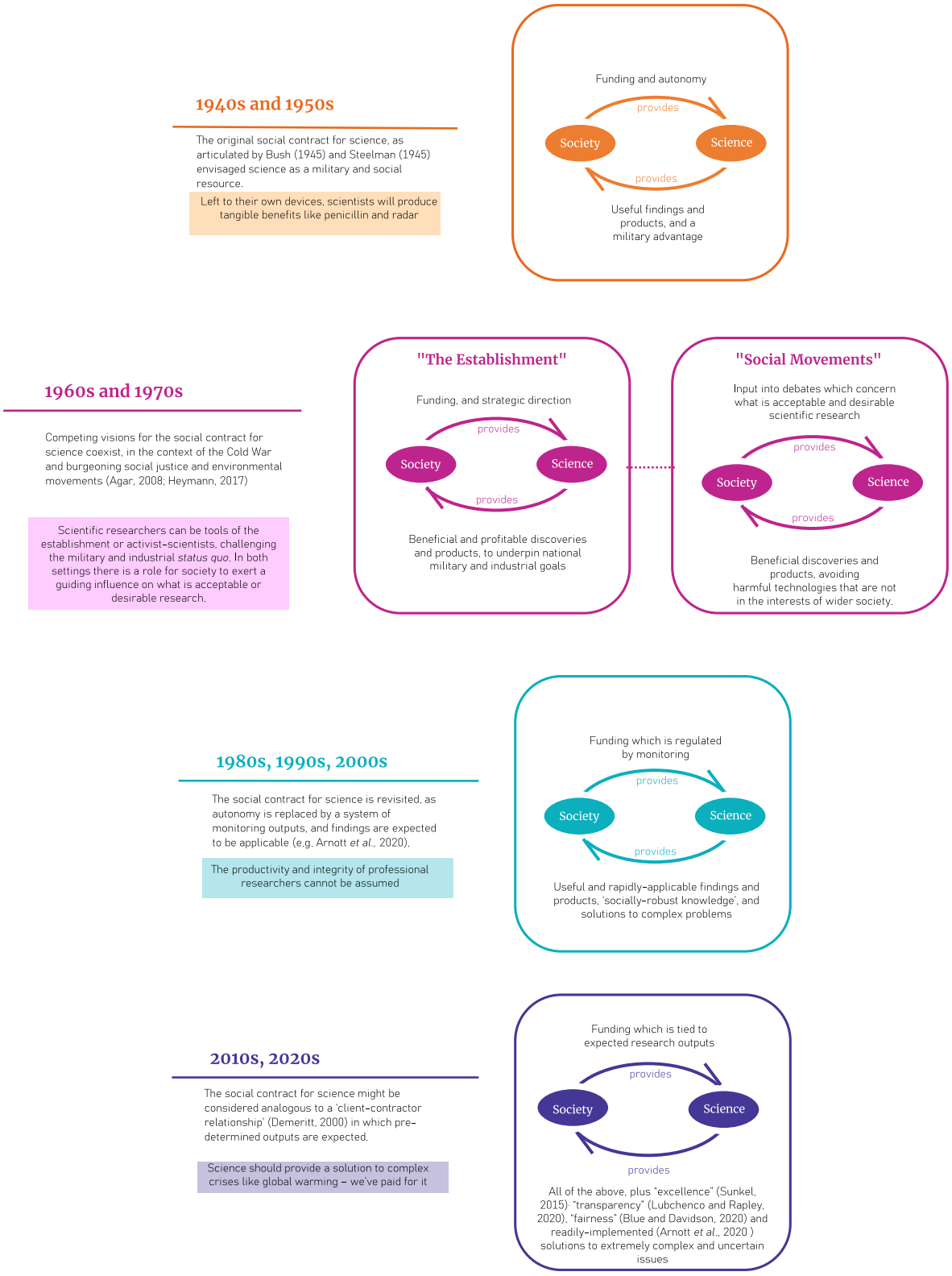

Fig. 1. The evolution of the Social Contract for Science.

themes have emerged as significant changes to the nature of that contract: the reduction in the flexibility and autonomy of the scientist; the loss of the assumption that science is a trusted tool for 'good'; and the emergence of a sense of urgency, with the timescales over which 'results' are expected becoming shorter, with less tolerance for exploratory research and 'eventual' benefits to society. Contextually, philosophers of science have identified significant contextual changes over the same period; for example, the version of a social contract for science which existed in the mid-20th century assumed that there was a meaningful distinction between basic and applied research, and this distinction has since been subject to critique (Douglas & Branch, 2024). Indeed, writing at the start of the 21st Century, the Geographer David Demeritt argued

that "the pace of technical and commercial change is now so rapid as to dissolve traditional distinctions between basic and applied research" (Demeritt, 2000, p. 315). Another key contextual change is the questioning of the "value-free ideal" which solidified in the mid 20th century (see: Douglas & Branch, 2024), with assertions that science is not "value-free" gaining prominence (see Douglas, 2000 on Inductive Risk; Douglas & Branch, 2024 on the supporters and critics of the value-free ideal). Other authors have suggested that the 21st century decline of investment in basic research within established scientific disciplines may be due to a growing recognition for the requirement for interdisciplinary and transdisciplinary research to address complex societal challenges (Hoyningen-Huene, 2009). Accordingly, considering the changing nature of the social contract for science also requires considering the structure of scientific research activities, and the potential relevance and prominence of disciplines and disciplinarity.

1.2. A brief (parallel) history of modernism and its successors

There is an increasingly prevalent argument that both science (the outcome) and the scientist (the agent) are integral to understanding the nature and practice of science (Morgan et al., 2023). The core of this argument is that science is carried out by people who are operating within cultural, economic, historical, regional, and philosophical paradigms. In works which explore the perception of science, 'science' is often perceived to be inextricable from the concept of 'modernity' (e.g. Miedema, 2022; Nowotny et al., 2001; Shapin, 2007), and therefore considering 20th Century science in the context of the philosophical schools of Modernism, Post-modernism, Reflexive Modernity, Liquid Modernity, and Metamodernism become pertinent to developing an understanding of the changing Social Contract of Science, and the relationship between science and society.

1.2.1. Modernism

Modernism is an optimistic and influential philosophical school of thought which emerged from the Enlightenment (Pipere & Mārtinsone, 2022). Modernism is characterised by a belief in objective truth which can be accessed through reason, experiment, and experience (i.e. logical positivism (Park et al., 2020)) and an almost utopian assumption of linear progress and subsequent societal improvement over time (Pipere & Mārtinsone, 2022). Modernism suggests that rationality and reason will result in beneficial inventions, which will in turn ensure a prosperous future (Franco-Torres, 2021; Pinker, 2018), a narrative which could be seen, for example, within early enthusiasm for 'atomic' energy (Welsh, 2000). One of the most important facets of Modernism when considering the interactions between Science and Society is the assumption of objective truth. In the Modernist understanding, facts might be considered analogous to fish in the ocean; they objectively exist, and the job of researchers is to catch them, or to devise new and ingenious equipment to assist in catching them (see: Latour, 1993, for a discussion of the implications of this assumption upon the anonymity of the scientific author). Towards the end of the 20th Century, a new variant of Modernity, 'Reflexive Modernity', was proposed (e.g. Beck, 1992a; Beck, 1998; Giddens, 1991, 1994, 1998; Kerr & Cunningham-Burley, 2000; Ray, 1999). This reformulation emphasised the creation and management of risk as central to the modern condition (e.g. Beck, 1988, 1992b, 1995, 1996, 1997) and incorporated a discourse surrounding the potential for science to fail to predict, to prevent, or to protect against risks to society (Elliott, 2002; Pipere & Mārtinsone, 2022). With a growing perception that Modernism did not realise the promises of mastery of nature, authority of science, linear progress and the utopian promises of betterment (Pipere and Mārtinsone, 2022), the core tenets of Modernism (including the belief in objectivity) were challenged by later schools of thought, such as Postmodernism.

1.2.2. Postmodernism

Postmodernism emerged in the latter half of the 20th Century, and challenged each of the core principles of Modernism (Bauman, 1992; Bertens, 1995; Butler, 2002; Pipere and Martinson, 2022; Thompson, 2017). While Modernism presents truth as objective, Postmodernism asserts that 'knowledge' or 'facts' are constructed, contingent upon the language used (see, e.g. Derrida, 1967), the practices and cultures which surround them (e.g. Foucault, 1970, 1975), and should be considered inescapably shaped by relationships of power (e.g. Foucault, 1977). While Modernism presents "grand narratives" of progress, Postmodernism asserts that history is incoherent and encourages scepticism about 'metanarratives' which attempt to frame experience and knowledge (Pipere and Martinson, 2022; Lyotard, 1979). Proponents of Postmodernism adopt a position of nihilistic irony and distrust (Pipere and Martinson, 2022), while also questioning assumptions of linear history (e.g. Baudrillard, 1994). This brief summary of Postmodernist thought presented here is clearly by no means comprehensive, and the work of Gilles Deleuze, Felix Guattari, Roland Barthes, Pierre Bourdieu, and Antony Giddens have made important contributions to the corpus of theory (e.g. Bertens, 1995; Butler, 2002; O'Donnell, 2003). However, in considering how a community of professionalised scientific researchers might interact with a wider society, the core Postmodern idea relevant here is the assertion that facts and knowledge are constructed and contingent (i.e. Social Constructionism). Much like the ethnographies and anthropological studies of scientific sites which appear in the disciplinary writings of STS (e.g. Hess, 2001; Latour, 1987; Latour & Woolgar, 1986), the assertion is that there is no such thing as objectively true facts, but only cultural and individual interpretations of information. In science, where knowledge is gained through observation, experience and learning, any challenges to the authority and objectivity of this knowledge challenges the nature of science itself (a good example can be found in the tension between science and law when science evidence is presented in court (Jasanoff, 2006; Lawless, 2022)). Postmodernism raises questions about the hierarchy between researchers and the public (a topic also explored by, for example, Thorpe & Gregory, 2010; in the context of the critique of the 'deficit model' of public understanding of science, and Gregory & Lock, 2008), and about the legitimacy and neutrality of scientists. Indeed, one of the prominent strands of criticism of Postmodernism and Social Constructionism is that if it were accepted, it would create a problematic environment for science of 'cognitive relativism' (Sokal & Bricmont, 1997). It has been argued that changes to cultural assumptions and values between Modernity and Postmodernity had significant effects upon cultural perceptions of science, and of scientific researchers (e.g. Forman, 2007, 2010, 2012). For example, it has been observed that the shift from Modernity to Postmodernity saw an inversion of the assumed cultural importance or value of science and technology, with Modernism placing greater value on science, and Postmodernity placing greater value on technology (Forman, 2007, 2010). Forman also suggested that academic disciplines were framed by the cultural values of Modernity, and that the inversion of many of the cultural assumptions of Modernity within Postmodernity created an environment in which prevailing cultural values were incompatible with the values of disciplinarity (Forman, 2012). Of particular relevance when considering the concept of 'The Social Contract for Science' alongside the shift from Modernity to Postmodernity, was the perceived cultural value of autonomy (see Forman, 2012, p. 84); that within Modernity autonomy for 'disinterested' entities was supported, while within Postmodernity deep scepticism was expressed for the concept of being 'disinterested', and therefore the autonomy of entities which might have been perceived as "pretending to serve the public interest" (Forman, 2012, p. 84) was revoked. At the same time, a shift in the cultural valuation of 'means' versus 'ends' was observed, with Postmodernity placing greater importance on 'ends', in the context of an "audit society" (Forman, 2012, p. 76). It might be noted that this contraction of autonomy, and focus on auditing is very similar to the theme of 'accountability' in the context of the social contract for

science (Demeritt, 2000, p. 309).

1.2.3. Other successors: Metamodernism and Liquid Modernity

Another iteration of Modernism, like 'Reflexive Modernity' mentioned in 2.2.1, is the concept of 'Liquid Modernity', as advanced by Zygmunt Bauman (e.g. Bauman, 2000, 2005, 2007). Liquid modernity considers the world to be moving from solid (and stable) to liquid, becoming "prone to change", and becoming defined by inconsistency and mobility (ibid.). Some authors have explored whether this 'liquidity' has impacted the practice of scientists (e.g. Mattiazzi & Vila-Petroff, 2021), tying Bauman's concept of liquidity (e.g. Bauman, 2000, 2005, 2007) into the concrete examples of the practices of publication, the demands of competition and speed, and the consequences for the quality and intentions of outputs (e.g. Batko, 2014; Ioannidis et al., 2005; Ioannidis et al., 2018; Mattiazzi & Vila-Petroff, 2021). Beyond 'Liquid Modernity', 'Metamodernism' has been referenced with increasing frequency since 2010 (Pipere and Martinson, 2022), and combines the critical inflection of Postmodernism with the belief in progress which lies at the heart of the original articulation of Modernism (Pipere & Mārtinsone, 2022; see also Metamoderna, 2022). Metamodernism acknowledges complexity, uncertainty, crisis, and decline, ideas which are sometimes associated with Postmodernism (Franco-Torres, 2021; Pipere & Mārtinsone, 2022), at the same time as expressing hope in science and technology as forces for advancement and improvement, which is characteristic of a Modernist standpoint (ibid.). In terms of the stance on (meta)narratives, Metamodernism acknowledges that the current prevailing narrative includes multiple crises, with multiple events and processes framed as potentially apocalyptic, and 'wicked problems' (Rittel & Webber, 1973), for which "an optimal or definitive solution" cannot be identified (Pipere & Mārtinsone, 2022, p. 7). One such example could be the wasteful manufacturing and disposal practices for textiles, where solutions must be implemented across geographically fragmented global supply chains, where there are multiple groups of stakeholders with conflicting goals and values, where proposed solutions would create new problems, and where change is not just technically complex, requiring the development of new recycling processes, but are socially complex, requiring significant behavioural change, and integration into existing economic models, or the implementation of innovative new economic paradigms. The idea of crisis sits at the core of Metamodernism, with Pipere and Mārtinsone (2022) outlining the idea of 'Metacrisis', or multiple simultaneous crises temporally overlapping and conceptually intersecting (see also Rowson, 2020). Under Metamodernity, the perception of crises and risks have changed; moving from a world defined by the acronym 'VUCA', standing for volatility, uncertainty, complexity, and ambiguity, which was articulated in studies of leadership (Bennis & Nanus, 1985) and later used to describe the world following the collapse of the USSR (see, e.g. Mack et al., 2015); to a world defined by the acronym 'BANI', denoting brittleness, anxiety, non-linearity, and incomprehensibility (see: Cascio, 2020; Pipere & Mārtinsone, 2022). Indeed, *"In the new world where VUCA meets BANI, the role of science in general and the tasks of different fields of science should be changed as they reorient from the solutions to inner problems of narrow, specific disciplines in a context of division of labor and in a framework of the discipline's own cultural, technological, and/or organizational structures to the overall coordinated assistance for humankind to deal with the complex and nonlinear problems and their consequences." [Direct Quotation from* Pipere & Mārtinsone, 2022, *p. 2]*. Here, it is possible to note similarities to the concept of "Post-normal science" advanced by Funtowicz and Ravetz (1993; 2018), where researchers are considered to be operating in situations of high 'systems uncertainty', and high 'decision stakes'. Pipere and Mārtinsone advance that it is possible to envisage an optimistic future if brittleness can be addressed by capacity and resilience, anxiety countered with empathy and mindfulness, nonlinearity woven into our understanding of context and tackled with adaptivity, and incomprehensiveness met with transparency and intuition (Pipere & Mārtinsone, 2022). At the same time however, Pipere and *Mārtinsone* suggest that a Metamodernist world, defined by metacrises, and a 'BANI' situation, would require a shift in the dominant mode of communication within debate, moving from a prevalent model of dialogue to a dominant model of 'polylogue' where multiple positions are considered (see: Kristeva, 1977; Sardar & Sweeney, 2016, ibid.), and where participants acknowledge that contradictions can not necessarily be resolved but they can be transcended (Pipere & Mārtinsone, 2022).

1.2.4. Changes over time

The characteristics of the different forms of Modernism are presented in Table 1. Three themes of significant change emerge when thinking about the relationship between scientists and society: (i) the shifting understanding of the world and of truth, in which the model of objective truth derived from a comprehensible world has become supplanted by a framework which presents constructed and plural truths, themselves derived from a complex, changing, threatened, and possibly incomprehensible world; (ii) an identification of acceleration and urgency, whereby a narrative of linear progress has been supplanted by narratives of fragility; and (iii) a reframing of the drivers of research, whereby themes of the utopian and progress have been supplanted by themes of the dystopian, and questions of survival.

2. Discussion

Having briefly outlined the evolving theoretical frameworks of the Social Contract for Science and the different philosophical schools of Modernism, Postmodernism, and Metamodernism, a juxtaposition of these two different bodies of theory offers interesting insights. Here, we outline points of similarity, the potential to apply these theories to the tension that exists in the relationship between wider society and science undertaken in universities, and the impact of the 'cultural tails' of such theories.

2.1. The social contract for Science and the different schools of philosophical thought are underpinned by similar core themes

While the Social Contract for Science and the philosophical schools of Modernism, Post-Modernism, and later successors such as Metamodernism may appear quite different, having emerged separately, and under the aegis of different disciplines, both are underpinned by similar core themes. Both bodies of theory encompass the idea of a loss of trust; for the Social Contract for Science, this is expressed as a loss of trust in researchers, and a move away from an expectation of autonomy and towards a mode of regulation of activities by assessment (see: e.g. Guston, 2000; Martin, 2011; Smith et al., 2011). For the frameworks beginning with and emerging from Modernism, a loss of trust in the idea of 'truth' can be seen – with a model which suggests an objective truth (i.e. Modernism) becoming supplanted by models which present the idea of truth as either a constructed artifact of language, culture, practice, and gradients of power (i.e. Postmodernism, after Foucault) or uncertain (i.e. Metamodernism) (see: Pipere & Mārtinsone, 2022).

A second theme that is shared by both theoretical frameworks is the idea of acceleration; Liquid Modernity is explicitly concerned with acceleration, the idea of constant change, and that the speed of outputs and innovation should be increasing (e.g. Bauman, 2000, 2005, 2007). This aligns with a similar shift observed in the reiterations of the Social Contract for Science, where the earlier writing on the relationship between researchers and wider society assumed that basic research would, in time, result in applied innovations (e.g. Steelman, 1947), later reiterations and suggestions for amendment to the contract acknowledge that there is now a preferential drive towards research where the findings are 'actionable' or readily implemented (e.g. Arnott et al., 2020), and suggest that scientific researchers should respond directly and urgently to emerging challenges. In addition, there is an expectation that researchers should demonstrate their productivity by the frequent (and measurable) publication of academic articles (see: e.g. Denning, 1997;

Table 1
A summary of the prevailing concepts for Modernism, Postmodernism, and Metamodernism.

School	The world	Truth	Research is …	Narratives	Tone
Modernism	Knowable	Objective	Driven by reason, rationality, and improvement	Grand and utopian narratives of progress	Optimism
Postmodernism	Unknowable	Constructed	Inextricable from the interests of power	Distrust and rejection of sweeping metanarrative	Cynicism
Metamodernism	Threatened	Plural	Necessary for survival in a 'BANI' world of metacrises	A recognition of plural narratives of destruction and crisis	Anxiety

Elton, 2000; Ioannidis et al., 2018).

As a third point of parallel, it can be suggested that both bodies of theory are underpinned by the idea of crisis and risk. The most recent iterations of the modern Social Contract for Science invoke the concept of risk as it intersects with and impacts upon the acceptability of research (see: e.g. Jasanoff, 2003), an idea expressed within discussions of potentially disruptive technologies as 'no innovation without representation' (e.g. Michie & Sheehan, 1999; Mitcham, 1997). Metamodernism also incorporates a dimension of crisis and risk, at its core engaging with a sense of permanent emergency or 'Metacrises' (see: Pipere & Mārtinsone, 2022). Accordingly, using Metamodernism as a framework, the types of research which society sanctions as worthwhile can be framed through a lens of imminent disaster and destruction - a very similar position to that expressed by the most recent reiteration of the Social Contract for Science.

2.2. Holding both theories simultaneously illuminates some of the miscommunications and frustrations observed between science and society

An awareness of the Social Contract for Science and its reiterations may help to shed light on some of the tensions which exist between scientific researchers and wider society. For example, tension can arise due to different understandings of the terms of the contract, and the extent to which the contract is honoured. For example, there may be a perception on the part of the public and politicians that the original contract is still intact, and scientific funding is adequate-to-generous, and that scientific researchers are given significant amounts of autonomy in their work (e.g. Research Professional News, 2024). By contrast, there is a perception from some scientific researchers that funding levels are inadequate (e.g. Roulston, 2021) and entangled in structures of bureaucracy (Lee & Walsh, 2022) that have eroded academic freedom. Simultaneously holding an awareness of the different schools of Modernism and its successors may also help to shed light on sources of tension, uncertainty, friction, or contradiction. For example, it is possible to suggest that many scientists operate with certain aspects of Modernist beliefs in place; the scientific method is predicated on the idea that there is an objective truth which can be sought, and logical positivism and falsification are considered by some to be key elements of science (e.g. Sismondo, 2010). In contrast, in the context of a Postmodern society where the idea that 'truth' and 'facts' are constructed by language and practice, and inextricable from power relationships prevails (as expressed in e.g. Bertens, 1995; Foucault, 1970, 1975, 1977; Pipere and Mārtinsone, 2022), there may be tension between researchers who believe that they are engaged in a effectively neutral search for 'true' facts, and those who do not subscribe to 'neutrality' or 'true facts'. The more utopian narrative of progress of Modernism might also be seen as incompatible with the dystopian narrative of disaster, crisis, and risk of Metamodernism. Given that both positions are held, the importance of polylogue (as in Kristeva, 1977; see Pipere & Mārtinsone, 2022) becomes ever more salient to navigate different viewpoints which cannot be resolved acceptably through compromise, but must instead be transcended (ibid). Indeed, although this paper foregrounds the concept of the Social Contract for Science, it is equally possible that the juxtaposition of the two bodies of theory might equally inform an exploration of the concept of Modernity.

2.3. The importance of narrative

One of the key distinctions between Modernism, Postmodernism, and Metamodernism is how each proposes to engage with, endorse, or reject (meta)narratives. Generally speaking, Modernism presents a utopian narrative of progress, Metamodernism engages with a dystopian narrative of crisis, while Postmodernism suggests that overarching grand narratives should be met with scepticism and rejection (Pipere & Mārtinsone, 2022). The idea of narrative also features heavily in the idea of the Social Contract for Science. The Social Contract for Science is itself a narrative, telling a persuasive story about the utility of science and the necessity of providing resources to scientists (e.g. Steelman, 1947).

Significant academic study has been carried out into the dynamics and effects of narratives, with some suggesting that narratives can be influential (Cadillo-Benalcazar et al., 2021), persuasive (Faddoul & Chatterjee, 2020), and offer a way to navigate complexity (Allen & Giampietro, 2006) since narratives do not have to be about objective reality, but rather assertions of what is significant (Allen & Giampietro, 2006, p. 595). Indeed, some propose that the value of narrative is made clear during crisis, with the observation that in difficult times, leaders tend to use metaphors and storytelling (Gkalitsiou & Kotsopoulos, 2023). Others propose that the collection and juxtaposition of narratives may itself form a research technique, in the form of 'Quantitative Storytelling' (see: e.g. Blackstock et al., 2023; Cadillo-Benalcazar et al., 2021; Di Felice et al., 2023). Proponents argue that attempts to represent the different narrative frames around an issue (e.g. Blackstock et al., 2023), can successfully accommodate plural viewpoints (e.g. Di Felice et al., 2023). Accordingly, given that the most recent iteration of the Social Contract for Science and the most recent theory on Metamodernism both suggest that researchers must find ways of navigating complexity and enabling polylogue, it is possible to suggest that engaging with narratives should be considered an important practice for science.

3. Conclusion and future directions

The Social Contract for Science offers a framework for imagining a transactional relationship between a community of professional scientific researchers and wider society (e.g. Bush, 1945; Steelman, 1947). In the decades since it was first outlined, amendments and reiterations have been proposed (e.g. Blue & Davidson, 2020; Gibbons, 1999; Lubchenco, 1998; Lubchenco & Rapley, 2020; see Fig. 1), and a development of the original contract's exchange of funding and autonomy from society for beneficial discoveries and products from scientists, has become seen as more of a 'customer-contractor relationship' (Demeritt, 2000). In this evolved contract the funding that is provided for research is tied to expected outputs, and readily-implemented findings are required (Arnott et al., 2020). Given the intrinsic connection between science and the scientists that undertake it, considering the Social Contract for Science together with the developments within Modernism, Postmodernism, and Metamodernism offers valuable insight, charting changing standpoints on the nature of the world, the nature of truth, the drivers behind research, and the grand narratives which might be seen to frame research (see Table 1). Both the Social Contract for Science and the philosophical schools of Modernism, Postmodernism, and Metamodernism deal, at their core, with questions of trust in the profession of research, expectations of acceleration, and a consideration of the

concept of risk.

Juxtaposing these two bodies of theory offers insights into these underlying themes, and potentially creates opportunities to suggest ways of navigating uncertainty, complexity, confusion, and dissatisfaction that frame the endeavour of university science, and shape the next iteration of the Social Contract for Science. Both the most recent iterations of the Social Contract for Science and of Metamodernity propose that transparency and the accommodation of multiple perspectives are vital to modern science, and that the role of modern science may be to operate within the context of 'wicked problems' or 'metacrises' in the context of narratives of urgency and emergency. Accordingly, considering both perspectives and the underlying themes of the profession of research, expectations of acceleration, and the concept of risk simultaneously may help to frame questions of practice which span both the sciences and the Arts and Humanities.

The original Social Contract for Science offered optimism and hope for the outcomes of research to be valuable to society across a broad range of critical concerns, from enhancing the standard of living to matters of security and defence. For science to continue to offer insight and progress in a BANI world characterised by metacrises and anxiety, there is value in revisiting the Social Contract for Science. Reclaiming the trust that underpinned the contract in its original articulation, and incorporating the inflection of Metamodernity to ensure that transparency, multiple perspectives, polylogue, and autonomy are part of the Social Contract for Science going forward, appear to be urgent and necessary for both future science and society to thrive. For example, a degree of autonomy is arguably necessary to enable basic research that will eventually translate into tangible benefits in society; increased transparency must be imbued into science research to rebuild trust with broader society; and polylogue is going to be foundational to thriving relevant scientific research that is conducted both with and for society.

There is significant potential to build a more open and transparent research culture that engages meaningfully with society. If it is possible to increasingly situate science research activity in a context of bringing together a broader understanding of society that accommodates both the Social Contract for Science and the philosophical schools of Modernism, Postmodernism, and Metamodernism, it is feasible to build an ecosystem that is more able to accommodate cross disciplinary interaction and cross-sector polylogue (although it may be important to recognise that the potential benefits of plurality may also accommodate some perspectives that are epistemically harmful). To build an ecosystem that will accommodate cross-disciplinary and cross-sector polylogue will require a diversity of approaches to scientific research and also a diversity of approaches in its applications to societal challenges; recognising this requirement for a diversity of approaches is a positive step to creating a more vibrant, agile, resilient ecosystem of science research that is able to engage with the brittle, anxious, non-linear, incomprehensible world. This will only be possible if recognition and reward for diverse approaches, thinking and application can be woven into the academic structures within which many researchers are working.

Science and the societies within which science is undertaken are dynamic and evolving. It is clear that deep questions have been raised in the light of recent polemics in science related to global climate and public health. As such the Social Contract for Science may be due the next iteration.

CRediT authorship contribution statement

R.M. Morgan: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **E.A. Levin:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **R. Haslam:** Writing – review & editing, Conceptualization. **M. Biriotti:** Writing – review & editing, Conceptualization.

Data availability

No data was used for the research described in the article.

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