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SCIENTIFIC EXPERTISE IN DEMOCRATIC CONTEXTS: TOWARDS REFLEXIVE AND INCLUSIVE GOVERNANCE

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Abstract

This paper critically examines the contested relationship between scientific authority and democratic legitimacy—two foundational pillars of contemporary governance whose normative underpinnings and institutional logics often stand in tension. Whereas science is grounded in methodological rigour, empirical validation, and claims to universality, democratic systems are premised on inclusivity, deliberation, and the contestation of values and interests. Drawing on science and technology studies, democratic theory, and epistemic governance, this paper addresses how to reconcile the asymmetrical epistemic capacities of scientific experts with the normative imperative of citizen participation in democratic decision-making. Employing qualitative methods, including content and thematic analysis of key academic literature published between 2004 and 2024, the paper maps the conceptual terrain of the science–democracy nexus. The findings suggest that, while scientific expertise remains indispensable to effective governance, its institutional integration frequently creates a technocratic deficit, resulting in limited deliberative engagement from the public, thereby undermining democratic legitimacy. The paper hypothesises that innovative participatory mechanisms offer a promising pathway towards reconciliation; however, empirical evidence indicates that such models remain largely underdeveloped and inconsistently implemented. By analysing contemporary configurations of expertise within democratic institutions, this paper proposes a conceptual framework for reconfiguring the division of epistemic labour. It argues that cultivating epistemic pluralism and institutional reflexivity is vital not only for enhancing the quality and legitimacy of policy outcomes but also for rebuilding public trust in both scientific and democratic processes. The paper concludes that democratic resilience in the face of complex, multi-dimensional challenges necessitates institutional innovations that actively bridge the epistemic divide between expert authority and participatory governance. The results offer clear guidance for policymakers and meaningfully advance discussions on expertise and public participation in democratic governance.

Keywords: Science, Democracy, Legitimacy, Participation, Governance, Crisis, Institutions

1. Introduction

Science and democracy are foundational institutions in contemporary governance. Scientific authority is based on empirical validation, methodological rigour, and reproducibility across contexts. Its authority is grounded in peer-reviewed consensus, empirical reproducibility, and falsifiability. While these criteria enhance reliability, claims to universality remain provisional and subject to ongoing scrutiny. Democratic legitimacy, in contrast to technocratic or authoritarian models, rests on four foundational principles: inclusive participation, which ensures that all citizens—regardless of status or identity—can engage meaningfully in political processes; electoral accountability, which enables the public to hold leaders responsible through free and fair elections; normative pluralism, which affirms the coexistence of diverse moral and cultural frameworks within a democratic society; and epistemic pluralism, the recognition that multiple valid ways of knowing—scientific, experiential, traditional, and more—contribute to public reasoning. Structural tension marks the interaction between these domains, as democratic systems must constantly negotiate between competing values, interests, and epistemologies. This tension intensifies in contexts of epistemic complexity, such as pandemics, climate change, and macroeconomic instability. These challenges demand both expert knowledge and democratic deliberation. The central issue lies in allocating decision-making authority between elected representatives and scientific experts. This tension gives rise to what scholars call the technocratic deficit—a condition in which democratic legitimacy erodes as authority becomes overly concentrated in unelected experts, sidelining public input and representative accountability.

Balancing technical expertise with participatory governance is essential to preserving democratic legitimacy in complex policy domains. This is not a theoretical dilemma; it has direct implications for crisis management, policy formation, and institutional trust. During the COVID-19 pandemic, for instance, governments relied heavily on epidemiological models and virological data to justify interventions. Yet public scepticism grew in response to inconsistent messaging, perceived infringements on civil liberties, and the politicisation of scientific advice.

Empirical research confirms that public trust in science varies across national contexts (Hendriks et al., 2016; OECD, 2024). These fluctuations correlate strongly with institutional transparency, media narratives, and the historic credibility of public agencies. Fladvad (2021) and Volacu & Aligica (2023) argue that governance based solely on expert authority lacks resilience unless it secures public legitimacy. Their findings suggest that technocratic decision-making is insufficient in democratic settings without mechanisms for civic engagement and contestation. Climate policy debates further illustrate this tension. Scientific assessments, such as those from the IPCC, consistently highlight the urgency of mitigation efforts. However, these assessments intersect with normative values, economic interests, and epistemic uncertainties (IPCC, 2014; 2022). Political divisions persist despite consensus on climate risks, particularly regarding the distributional impacts of carbon reduction strategies. Pamuk (2024) and Schroeder (2021) demonstrate that scientific expertise cannot substitute for democratic deliberation. Effective policy requires integrating scientific evidence into pluralistic processes that accommodate disagreement and manage uncertainty. Upholding democratic norms while responding to complex challenges remains a central task for contemporary governance.

This paper offers a systematic investigation of both the descriptive dimension—how science and democracy currently interact in practice—and the normative dimension—how they ought to be configured to uphold democratic legitimacy while effectively leveraging scientific expertise. It examines the institutional channels through which scientific knowledge is integrated into democratic decision-making, with particular attention to mechanisms that promote accountability and transparency in science advice. Additionally, it engages with normative debates concerning the appropriate role of citizens in shaping the production and application of scientific knowledge, drawing on theories of deliberative and participatory democracy (Bohman, 2004; Bader, 2013). These considerations give rise to three central hypotheses: H1. The integration of scientific expertise into democratic institutions is essential for effective governance, yet it introduces inherent tensions with citizen participation. H2. Democratic resilience relies on a dynamic equilibrium between epistemic authority (science) and democratic legitimacy (citizens). H3. Innovative participatory mechanisms—such as deliberative forums, citizen science initiatives, and citizen assemblies—offer models for reconciling the demands of expertise and democratic inclusion.

The overarching aim of this paper is threefold: to critically analyse the causal and conceptual relationships between science and democracy as articulated in the academic literature, moving beyond reductive dichotomies; to identify and assess best practises and institutional innovations that enable the integration of scientific expertise into governance without compromising democratic values; and to evaluate the significance of values, disagreement, and uncertainty in shaping the science-democracy interface. Legitimate democratic processes must address these intrinsic dimensions, which are not peripheral to scientific advice. By engaging with these themes, the paper seeks to advance a more complex conception of the conditions under which expertise can support—rather than displace—democratic governance.

2. Literature Review

Science & Democracy: Deliberation, Participation, and Crisis Governance

The relationship between science and democracy has long been a subject of debate across political theory, philosophy of science, and science and technology studies. Early scholarship often framed scientific expertise as a dilemma for democratic governance. Brown (2009) argued that while expert knowledge is indispensable for addressing complex societal problems, it can simultaneously undermine democratic representation by shifting decision-making power away from elected officials and citizens. In a similar vein, Durant (2011) examined how different models of democracy accommodate or resist the authority of science, highlighting persistent tensions between technocratic decision-making and participatory ideals. These anxieties reflected broader concerns about the concentration of epistemic authority within institutions not directly accountable to the public (Anastasiadou et al., 2021; Dryzek & Pickering, 2017; Feindt & Weiland, 2018; Kaplan et al., 2021; Krick, 2022; Moore, 2021; Valkenburg, 2020; Weingart, 2023). In response, scholars sought to bridge this gap between expertise and democratic legitimacy. Bohman (2004) proposed that deliberative democracy could function as a mode of inquiry, where scientific reasoning is strengthened by embedding it within inclusive public dialogue. Bader (2013) extended this idea by promoting associative democracy, in which diverse social actors participate in shaping expert domains, thereby democratising science and exercising democracy. More recently, Niemeyer et al. (2024)

provided empirical support for these approaches, showing how institutional mechanisms can structure deliberation to incorporate both expert input and citizen reasoning, even amid complexity and disagreement. Rather than seeing expertise as a threat, their findings suggest that it can be integrated into democratic processes through careful design and facilitation.

The turn toward deliberative and participatory models of democracy has been central in rethinking legitimacy. Brown (2009) argued that the challenge is not to eliminate experts but to manage their institutional representation in ways that preserve public trust and democratic accountability. This perspective resonates with broader conceptual work that views democracy as an inherently contested and evolving practice, requiring constant interpretation and negotiation (Boswell & Corbett, 2021; König et al., 2022). Such reframing has given rise to the notion of the "democratisation of science," which rejects the traditional deficit model of one-way knowledge transmission. Chilvers and Kearnes (2019) argue that citizens must be recognised not only as recipients of knowledge but also as active contributors to scientific governance.

Citizen science exemplifies this shift, offering potential for civic empowerment and more inclusive governance. Nevertheless, challenges remain. Herzog and Lepenies (2022) warn of epistemic injustice, where institutional experts devalue local or citizen knowledge. Battilana et al. (2022) extend this concern by drawing parallels between democratising science and democratising work, arguing for a redistribution of power within organisations and knowledge systems to foster inclusion and sustainability. These perspectives align with broader calls to reimagine norms of political equality in a rapidly complex and interconnected world (Anastasiadou et al., 2021; Benhabib, 2021; Dryzek & Pickering, 2017; Hansen, & Goenaga, 2021; Johnson, 2022; Kaplan et al., 2021; Krick, 2022; Moe, 2020; Moore, 2021; Valkenburg, 2020).

The fragility of the science-democracy nexus becomes most apparent during crises, when uncertainty intensifies reliance on expertise. Fladvad (2021) advocates for a pragmatist approach to crisis governance, warning that rigid institutional models often falter under dynamic pressures. Pamuk (2024) emphasises that even ostensibly "objective" scientific advice is infused with values and political judgments, underscoring the need for transparency and contestability to prevent technocratic overreach. Correspondingly, Volacu and Aligica (2023) conceptualise democratic resilience as the capacity of democratic norms to resist crisis pressure without delegating excessive authority to experts. The digital public sphere further complicates this relationship. Furthermore, Habermas (2022), Maati et al. (2023), and Schedler (2023) highlight how digitisation enables the rapid spread of misinformation, eroding institutional legitimacy and weakening the epistemic foundations of democracy. Clayton et al. (2021) provides empirical evidence that elite rhetoric can undermine democratic norms, further threatening trust in science and governance. These dynamics show that there are vigorous safeguards when scientific authority intersects with contested public discourse.

Despite this rich body of work, significant gaps persist. Much of the normative work remains conjectural, with little empirical inquiry into how governance structures operationalise the science-democracy nexus across diverse contexts. Hansen and Goenaga (2021) and Saikkonen and Christensen (2022) explore citizen attitudes toward democratic institutions, but there is the need to pay more attention to how these attitudes influence the legitimacy of science in governance. Schroeder (2021) advances the discussion by linking democratic values directly to public trust in science, but the institutional mechanisms that render these values transparent remain underdeveloped. In addition, democratic science has been widely endorsed (Benhabib, 2021; Moe, 2020; Johnson, 2022), but concrete institutional designs for balancing expertise and legitimacy are often underexplored. By synthesising these strands—from deliberative democracy (Bohman, 2004; Bader, 2013; Niemeyer et al., 2024) and knowledge co-production (Chilvers & Kearnes, 2019; Herzog & Lepenies, 2022; Battilana et al., 2022), to crisis governance (Fladvad, 2021; Pamuk, 2024; Volacu & Aligica, 2023; Valkenburg, 2020; Weingart, 2023) and digital challenges (Clayton et al., 2021; Habermas, 2022; Maati et al., 2023; Schedler, 2023)—this paper builds a unified framework for understanding the science-democracy nexus. It highlights both the risks of epistemic domination and the opportunities for democratic renewal through institutional innovation and participatory inclusion.

3. Method

This paper adopts a qualitative content analysis that enables a rigorous synthesis of the interdisciplinary scholarship concerning the relationship between science and democracy. The design is selected to fulfil two key objectives. First, it facilitates a descriptive map of how science-democracy interactions have been conceptualised across academic domains, identifying foundational arguments and empirical insights. Second, it supports the development of a normative-empirical framework for understanding the appropriate distribution of roles among citizens, democratic institutions, and scientific experts. This approach enhances the identification of convergences and tensions across diverse scholarly traditions—including political theory, science and technology studies, and public administration (Benhabib, 2021; Schedler, 2023). Instead of drawing conclusions from selective or

anecdotal interpretations, this meticulous approach ensures a comprehensive and balanced engagement with the literature.

Building on the hypotheses outlined in the introduction, a systematic framework is organised to examine their conceptual and empirical grounds across the selected literature. The first hypothesis addresses the tension between institutionalising expertise and the democratic imperative of citizen participation, suggesting that technocratic governance risks sidelining public input. The second explores how democratic resilience depends on maintaining a balance between epistemic authority and democratic legitimacy, emphasising that it requires integrative institutional designs. The third focuses on participatory innovations—such as deliberative forums, citizen science, and citizen assemblies—as practical mechanisms for bridging the divide between expert knowledge and democratic inclusion. These hypotheses serve as analytical anchors for assessing how democratic systems can navigate the science-democracy nexus without compromising core democratic values.

The data corpus for this paper consists of academic literature published between 2004 and 2024, including peer-reviewed journal articles, scholarly monographs, and edited volumes. The selection process was guided by a systematic protocol designed to ensure both relevance and disciplinary breadth. Sources were identified through targeted keyword searches in major academic databases using terms including “science,” “democracy,” “legitimacy,” “participation,” “governance,” “crisis,” and “institutions.” In addition to database searches, reference chaining and citation tracking were employed to capture influential works that may not have appeared through keyword queries alone. To ensure the robustness of the corpus, three inclusion criteria were applied. First, all selected texts had to engage directly with the relationship between science, expertise, and democracy, whether from a theoretical or empirical standpoint. Second, the corpus was curated to include both foundational normative and theoretical contributions—such as those by Bohman (2004) and Brown (2009)—as well as more recent empirical studies, including those by Volacu and Aligica (2023) and Maati et al. (2023). This dual focus was essential for addressing both the descriptive and normative dimensions of the paper. Third, the literature was selected to reflect geographic and disciplinary diversity, encompassing works from political theory, philosophy, science and technology studies, and public administration. This ensured that the findings would not be confined to a single intellectual tradition or regional context. This diverse and curated corpus enables a rigorous exploration of the conceptual and empirical contours of the science-democracy nexus.

The analytical process was conducted in three interrelated stages, each designed to deepen the understanding of how the relationship between science and democracy has been theorised and empirically examined across the selected literature. The first stage involved a structured content analysis of each text in the corpus. A predefined coding scheme was applied to capture key dimensions of the science-democracy relationship. These included the institutional role of scientific expertise in governance, the mechanisms and norms of citizen participation, the conceptualisation of uncertainty and normative disagreement, the role of science and democracy in crisis governance, and discussions surrounding democratic legitimacy and resilience. Each text was read in full and coded manually to ensure interpretive depth and consistency. This stage enabled the systematic identification of recurring themes and conceptual tensions, forming the empirical foundation for the subsequent synthesis. In the second stage, a comparative thematic analysis was conducted to synthesise the coded data into broader conceptual clusters. This involved comparing and contrasting the arguments presented by different authors to identify patterns of convergence—such as a shared recognition of the necessity of expertise in policymaking—and divergence, particularly in views on the epistemic legitimacy of citizen participation.

Through this process, four thematic clusters were developed, which include science as institutional authority, democratic legitimacy and citizen participation, crisis and democratic resilience, and emerging hybrid models. These clusters reflect both descriptive and normative dimensions of the literature and serve as the scaffolding for the conceptual framework developed in the final stage. The third and final stage of the analysis focused on the development of an integrated conceptual framework. This framework connects the four thematic clusters to construct a holistic map of the science-democracy relationship. It links empirical observations with normative arguments, illustrating how expertise and participation interact within democratic institutions, especially under conditions of uncertainty and crisis. The framework also identifies institutional innovations—such as deliberative forums, citizen science initiatives, and citizen assemblies—as promising mechanisms for reconciling the demands of epistemic authority with the principles of democratic inclusion. By bridging descriptive analysis with normative theorising, the framework offers a structured lens through which to evaluate democratic governance in the age of expertise. It stands as the central analytical contribution of this paper and provides a foundation for future studies on the evolving interface between science and democracy.

4. Findings

Science as an Institutional Authority in Contemporary Governance

The findings substantiate the proposition that scientific expertise has become a pivotal institutional authority within contemporary governance, particularly in policy domains marked by technical complexity, uncertainty, and high-stakes decision-making. Science is no longer just a source of empirical knowledge; it now functions as a legitimising force that underlies administrative rationality and policy credibility. This transformation is evident in the increasing reliance on expert advisory bodies, modelling techniques, and evidence-based frameworks that inform governmental responses to multifaceted challenges—from climate change to public health emergencies. The COVID-19 pandemic offered a paradigmatic illustration: epidemiological models and virological expertise were not only instrumental in shaping containment strategies but also served as justificatory tools for exceptional policy measures, including lockdowns and vaccine mandates. However, the analysis reveals that the institutional elevation of scientific authority introduces a structural tension within democratic systems. Expertise enhances the precision and efficacy of governance, but it can simultaneously displace participatory mechanisms and recalibrate the locus of decision-making in favour of technocratic enclaves. This dynamic risks engendering what Brown (2009) terms a "democratic deficit," wherein the procedural norms of transparency, contestability, and civic inclusion are subordinated to epistemic imperatives. The concentration of authority among scientific elites—often insulated from public deliberation—can erode the legitimacy of policy decisions, particularly when those decisions affect fundamental rights or societal values. The COVID-19 pandemic context underscored this dilemma: While expert guidance played a critical role in shaping policy responses, this analysis highlights the absence of robust institutional mechanisms for integrating scientific and technical expertise into democratic decision-making which has contributed to public scepticism, political polarisation, and a gradual erosion of trust in government institutions.

These findings lend empirical support to H1, which posits that the integration of scientific expertise into democratic institutions is essential yet fraught with tensions. The results also illuminate the contours of H2, suggesting that democratic resilience hinges on a dynamic equilibrium between epistemic authority and democratic legitimacy. This equilibrium cannot be achieved through mere juxtaposition of expertise and participation; rather, it requires institutional architectures that actively mediate between the two. Such mediation involves procedural innovations that embed scientific input within frameworks of accountability, transparency, and civic engagement. For example, advisory panels must be complemented by mechanisms for public scrutiny, and expert recommendations should be subject to deliberative validation within representative bodies. Moreover, the findings point towards a broader insight: the challenge is not the presence of expertise per se, but the institutional configuration through which expertise is operationalised. Democratic systems must avoid both technocratic overreach and populist rejection of knowledge. Instead, they must cultivate reflexive institutions capable of integrating scientific authority without compromising democratic norms. Rethinking the design of governance structures is necessary to harness epistemic competence in ways that uphold, not weaken, democratic legitimacy. The results show that when expert knowledge is embedded within transparent, dialogic frameworks—such as citizen assemblies or science-policy interfaces—it enhances both policy effectiveness and public trust. In doing so, science can serve not as a substitute for public reasoning but as a partner in a deliberative democratic project that is both informed and inclusive.

Democratic Legitimacy and Citizen Participation in Science Governance

The second thematic cluster elucidates the complex relationship between democratic legitimacy and citizen participation in the governance of science. The findings reinforce the view that while participatory rhetoric is increasingly embedded in science policy discourse, its practical implementation remains uneven. Democratic legitimacy, as conceptualised within a deliberative framework, requires more than procedural inclusion; it demands substantive engagement, where citizens are afforded candid epistemic and normative influence in the formation of scientific knowledge and in policy decisions. Empirical analysis reveals that citizen participation is frequently instrumentalised and employed to confer legitimacy on decisions already shaped by expert consensus rather than foster reciprocal deliberation. This pattern is evident in various citizen science initiatives and public consultations, which, despite their participatory framing, often operate within tightly controlled parameters that limit the scope of public input. Such practises risk reinforcing existing hierarchies of knowledge and authority, thereby undermining the democratic promise of inclusion. The symbolic use of participation, while rhetorically potent, fails to address the deeper institutional asymmetries that inhibit meaningful engagement. The findings also highlight a gap between normative aspirations and institutional realities. While models of co-production and deliberative engagement are widely endorsed in theory, their operationalisation is constrained by structural

factors including informational asymmetries, bureaucratic inertia, and the dominance of epistemic elites. These barriers restrict access to decision-making processes and shape the terms on which participation occurs.

Citizens are often positioned as passive recipients of expert knowledge rather than as co-constructors of epistemic and normative frameworks. This dynamic limits the transformative potential of participatory mechanisms and perpetuates a technocratic mode of governance. In light of these challenges, the results point to the need for institutional innovation aimed at recalibrating the interface between science and democratic publics. Democratic resilience, as articulated in H2, depends on a dynamic equilibrium between epistemic authority and civic legitimacy. Achieving this balance requires participatory architectures that are not merely consultative but deliberative structures that facilitate reciprocal dialogue, contestation, and the integration of diverse forms of knowledge. Such mechanisms must be designed to accommodate plural epistemologies and value systems while acknowledging that scientific governance is not only a technical undertaking but also a normative one. Moreover, the findings lend support to H3 by identifying promising avenues for reconciling expertise with democratic inclusion. Deliberative forums, citizen assemblies, and co-creative platforms offer institutional models that, when properly resourced and embedded, can enhance both the epistemic quality and democratic legitimacy of science governance. This paper situates these structures within broader institutional ecosystems that promote transparency, reflexivity, and accountability. Through such systemic reform participatory practises can move beyond symbolic inclusion and contribute meaningfully to the co-production of knowledge and policy. Thus, the results reveal that democratic legitimacy in science governance is contingent not merely on the presence of participatory mechanisms but on their institutional design and normative orientation. Bridging the gap between expertise and public reasoning requires a reimagining of governance structures that foreground deliberation, inclusivity, and epistemic justice.

Crisis Governance and the Democratic Stress Test

The third thematic cluster interrogates the structural and normative pressures exerted on democratic institutions during periods of crisis, revealing how emergencies serve as crucibles for testing the integrity of democratic governance. The findings underscore a recurring tension: while crises necessitate rapid, expert-led responses, they simultaneously risk marginalising democratic norms, such as transparency, accountability, and public deliberation. Empirical evidence from Fladvad (2021) and Volacu and Aligica (2023) illustrates that crises—be they pandemics, environmental disasters, or geopolitical threats—tend to centralise authority and elevate technocratic decision-making. This concentration of power, while operationally expedient, often sidelines legislative scrutiny and civic engagement. The paradox is stark: the very mechanisms that enable effective crisis management may erode the participatory foundations of democratic legitimacy. In such contexts, scientific expertise becomes both indispensable and politically fraught. The politicisation of expertise emerges as a salient theme. Clayton et al. (2021) and Schedler (2023) document how elite actors strategically deploy scientific authority to advance partisan agendas, thereby undermining its epistemic neutrality. This dynamic transforms expert advice into contested terrain, where its legitimacy is judged not by methodological rigour but by ideological alignment. Digital misinformation and algorithmic amplification further exacerbate the erosion of trust in scientific institutions, as Maati et al. (2023) demonstrate. Their observational study of social media recommendation systems revealed that low-credibility content—especially posts with high engagement metrics and originating from influential accounts—was disproportionately amplified, often surpassing more reliable sources in visibility and reach. These dynamics destabilise public discourse, fragment epistemic consensus, and weaken democracy's capacity for collective reasoning by prioritising virality over veracity and reinforcing ideological echo chambers.

Against this backdrop, the findings affirm H3: Innovative participatory mechanisms offer a countervailing force to technocratic drift. Deliberative forums, citizen assemblies, and co-creative platforms can serve as democratic correctives, enabling publics to engage with expert knowledge in ways that are dialogic rather than deferential. However, their efficacy during crises hinges on institutional readiness and normative commitment. These instruments must be embedded in governance structures that prioritise openness, reflexivity, and contestation—even under conditions of urgency. Volacu and Aligica's (2023) minimalist conception of democratic resilience provides a compelling normative anchor. Rather than seeking procedural perfection, resilient democracies safeguard core principles—freedom of expression, pluralism, and institutional checks—even when expediency tempts deviation. The findings suggest that resilience is not merely a function of institutional robustness but of adaptive capacity: the ability to integrate expertise without relinquishing democratic oversight. Importantly, the analysis reveals that participatory innovation must be crisis responsive. Static models of engagement are ill-suited to the fluidity and volatility of emergency contexts. Instead, adaptive participatory infrastructures—capable of scaling, diversifying input, and facilitating rapid yet inclusive deliberation—are essential. This calls for a reimagining of democratic design, where citizen engagement is not an afterthought but

a constitutive element of crisis governance. Therefore, the findings show that crises highlight the gaps between expertise and democratic participation.

Technocratic governance, characterised by the delegation of decision-making authority to experts rather than elected officials, demonstrates short-term effectiveness in navigating complex policy domains, such as fiscal regulation, climate mitigation, and public health emergencies. It underscores that technocratic governance derives its strength from the application of specialised expertise and evidence-based reasoning, which enable effective responses to technically complex and high-stakes policy challenges. However, the data also reveal that this model carries significant democratic costs. Specifically, technocratic systems exhibit a consistent tendency to marginalise public deliberations and weaken institutional accountability, particularly when decisions are made beyond the scope of electoral oversight. This democratic deficit, as demonstrated in the analysis, contributes to public disengagement and declining trust in representative institutions, particularly in contexts where citizens perceive their values and preferences to be excluded from policy formulation.

This paper identifies a correlation between these exclusionary dynamics and increased support for populist movements, which often position themselves in opposition to elite-driven governance structures. This structure, with its emphasis on procedural rationality, efficiency, technical precision, and evidence-based decision-making, offers clear advantages in managing complex policy domains. However, this approach tends to marginalise normative debates and public deliberations. Technocratic regimes often obscure the embedded value assumptions in scientific advice, despite its perceived objectivity. A lack of transparency in governance processes can substantially increase the risk of political exploitation, particularly in situations where policy decisions are shaped by competing interests. Institutional credibility may suffer when decision-making procedures lack clear communication or public accountability, resulting in increased public scepticism. These dynamics are especially pronounced during crises—such as global pandemics or climate-related emergencies—where governments must act swiftly under conditions of uncertainty. In such contexts, the imperative for rapid intervention often intersects with contested societal values, amplifying scrutiny of political authority. Consequently, the legitimacy of democratic institutions becomes increasingly vulnerable, as citizens demand greater clarity and justification for decisions that affect fundamental rights and collective welfare. In light of these findings, the paper advocates for institutional innovations that embed expert input within participatory and transparent frameworks. These include, for example, co-regulatory bodies that facilitate structured dialogue between technical experts and lay stakeholders. Such hybrid architectures, as supported by the data, offer a means of preserving the epistemic integrity of scientific advice while enhancing democratic responsiveness. As policy environments become more complex and politically polarised, the imperative is not to reject technocratic expertise but to integrate it within democratic structures that reinforce legitimacy, inclusivity, and public trust.

Hybrid Governance and the Institutionalisation of Participatory Expertise

The final thematic cluster identifies the emergence of hybrid governance models as a strategic response to the tension between scientific authority and democratic legitimacy. Based on the paper's data, these models exhibit institutional arrangements that combine expert knowledge with mechanisms of public deliberation and participatory oversight. The findings reveal that such configurations are increasingly adopted in policy domains marked by high complexity and contested values—particularly in areas such as climate governance, digital regulation, and public health. These hybrid structures often include co-regulatory bodies, citizen assemblies, and deliberative councils, which serve to mediate between technical expertise and societal preferences. The analysis demonstrates that when designed with transparency and inclusivity, hybrid models enhance procedural legitimacy and foster trust in decision-making processes, without compromising the epistemic rigour of scientific input. This suggests a viable pathway for reconciling technocratic efficiency with democratic responsiveness in contemporary governance.

This analysis moves beyond the binary opposition between technocracy and populism, instead foregrounding institutional arrangements that integrate expert knowledge with citizen participation in a mutually reinforcing manner. This insinuates that while traditional science governance has often privileged expert-led decision-making, the data points to the viability of hybrid models that redistribute both epistemic and normative authority. Battilana et al. (2022) and Herzog and Lepenies (2022) illuminate a range of experimental configurations. These include democratised workplaces, citizen science platforms, and deliberative assemblies. Each of these models challenges the assumption that expertise and participation are inherently incompatible. These models do not merely consult citizens post hoc but embed them within the epistemic and deliberative processes that shape scientific and policy outcomes. Examples such as distributed advisory systems, participatory technology assessments, and deliberative mini-publics focused on scientific controversies demonstrate that lay

citizens, when supported by inclusive and accessible frameworks, are capable of engaging with complex scientific issues in informed and constructive ways.

The findings confirm H3, indicating that hybrid governance offers a way to reconcile the demands of scientific rigour with democratic legitimacy. However, a critical insight emerges: these models remain largely peripheral, often confined to pilot schemes, localised initiatives, or time-bound projects. Their marginal status reflects a broader institutional inertia within science-policy interfaces, where established norms and bureaucratic structures resist the integration of participatory innovation. The transformative potential of hybrid governance risks dilution or co-optation in the absence of sustained political will and structural reform. Battilana et al. (2022) argue that for hybrid models to exert systemic influence, they must be institutionalised—embedded within the core architecture of governance rather than added as experimental supplements. This entails reconfiguring decision-making processes to accommodate plural epistemologies, fostering cultures of reflexivity within scientific institutions, and ensuring that participatory mechanisms are adequately resourced and protected from tokenistic appropriation. Institutionalisation also requires legal and procedural safeguards that guarantee continuity, transparency, and accountability, thereby enabling participatory expertise to shape policies over time rather than episodically. This calls for a paradigmatic shift in science governance: one that moves beyond ad hoc participation towards sustained, embedded democratic engagement. Such a shift would entail not only the redesign of institutional structures but also a reorientation of epistemic norms—recognising that scientific knowledge is not produced in isolation but co-constructed through dialogue with diverse publics. Hybrid governance, in this sense, is not merely a technical remedy but a normative commitment to epistemic justice and democratic pluralism. Thus, the findings affirm that hybrid governance models represent a viable and necessary evolution in the science-democracy nexus. Their success, however, will depend on whether they transition from peripheral innovation to institutional mainstream—becoming foundational components of democratic governance rather than experimental exceptions. The future of resilient, inclusive science policy lies in this institutional reimagining.

5. Discussion

Navigating the Legitimacy Dilemma in Science-Democracy Integration

The results confirm that the integration of scientific expertise into democratic institutions (H1) is both indispensable and fraught with contradictions. On the one hand, expertise enhances the capacity of democratic systems to respond effectively to complex challenges such as climate change, public health crises, and technological risks. Conversely, the authority conferred upon experts may inhibit citizen engagement, resulting in legitimacy challenges that erode the democratic principles of governance. These tensions cannot be resolved by privileging either expertise or democratic legitimacy in isolation; rather, as H2 suggests, resilience depends on a dynamic equilibrium between epistemic authority and citizen voice. Innovative participatory mechanisms (H3) offer avenues to recalibrate the balance between epistemic authority and democratic legitimacy. The findings highlight deliberative mini-publics, citizen assemblies, and participatory budgeting as institutional innovations that embed citizen voice within expert-driven policy domains (Bohman, 2004; Bader, 2013). These mechanisms not only enhance procedural legitimacy but also foster epistemic diversity, enabling publics to contest, co-produce, and validate expert claims. However, their institutionalisation remains uneven, often constrained by technocratic inertia, limited political will, and fragmented governance structures, suggesting that their transformative potential hinges on sustained integration into decision-making architectures and adaptive learning across contexts (Hansen, & Goenaga, 2021; Herzog & Lepenies, 2022; Niemeyer et al., 2024; Saikkonen & Christensen, 2022).

Brown (2009) argued that expertise is indispensable but must be institutionally mediated if legitimacy is to be preserved. He presents the representation of expert knowledge within political institutions as a central challenge for democracy. The findings support this claim by demonstrating that institutional mediation frequently proves inadequate in practice, particularly in conditions of crisis where expert-driven decision-making tends to dominate. This suggests that mediation must be understood not only as a matter of institutional design but also as a test of resilience under stress. Similarly, Durant's (2011) typology of democracy in science studies classifies models along a spectrum from technocratic to participatory. While Durant treats these models as distinct, the findings indicate a growing interest in hybrid arrangements that combine elements of both expert authority and citizen input. This suggests that the division between technocracy and participation is less rigid than Durant originally proposed. Bader (2013) advances the notion of "associative democracy" as a means of simultaneously democratising science and exercising democracy. This analysis supports that vision, but it emphasises that associative mechanisms, if confined to the margins of governance, cannot resolve the legitimacy crisis. Rather, strengthening democratic authority requires deeper integration into the core of institutional decision-making.

The deliberative democratic framework provides further points of comparison. Bohman (2004) defines deliberation as an inquiry mode where public reasoning co-constructs facts and values. This finding supports such

a view but shows that deliberative forums often face difficulties in influencing policy outcomes, particularly under time constraints. Niemeyer et al. (2024) reinforce this point by identifying the conditions that enable deliberative reasoning, which the findings confirm, while also stressing that such processes must be insulated from elite dominance if they are to achieve their intended legitimacy. Chilvers and Kearnes (2019) highlight the increasing prominence of co-production in science-democracy relations. This paper confirms the rise of co-production as a paradigm while drawing attention to its uneven and selective implementation, typically in less politically contentious fields. Herzog and Lepenies (2022) argue that citizen participation can redress epistemic injustice by validating diverse forms of knowledge. The results extend this view, suggesting that citizen participation initiatives promote inclusion and contribute to democratic resilience by providing alternative channels for engagement when technocratic tendencies dominate. Pamuk's (2024) work highlights the dangers of depoliticisation, cautioning against the use of expertise to circumvent political debate. While acknowledging the risks inherent in the politicisation of scientific discourse (Moore, 2021; Valkenburg, 2020; Weingart, 2023), this paper contends that science cannot be regarded as apolitical. Scientific advice—particularly within the context of policy-making—is frequently shaped by implicit values and vested interests that influence both the formulation of enquiries and the interpretation of empirical evidence. The principal concern lies not in the mere presence of political influence, but in the covert embedding of normative assumptions within what is presented as objective, value-neutral expertise. This underscores the role of non-epistemic values—such as political, economic, and moral considerations—in determining the perceived relevance and significance of scientific findings. Although science aspires to uphold the ideal of value-freedom, expert advice often reflects broader societal priorities and normative goals. To preserve public trust, scientific institutions in democratic societies must be transparent about these influences.

Moreover, scientific knowledge constitutes only one of several inputs into policy decisions. Failure to disclose the normative assumptions and value judgements underlying scientific advice can undermine its perceived neutrality. This lack of transparency can diminish public trust in expert institutions, particularly in areas such as climate policy, public health, and emerging technologies, where contested values often shape both scientific interpretation and political decision-making. The politicisation of science can manifest through deliberate emphasis on scientific uncertainty, a rhetorical strategy that shifts the burden of proof and reframes consensus as inconclusive. This approach exploits the inherent tentativeness of scientific inquiry to justify regulatory inaction or reshape public understanding. The study shows that such tactics can distort risk perception, hinder timely decision-making, and erode the epistemic authority of scientific institutions by conflating scientific debate with political controversy. Schroeder (2021) similarly stresses that trust in science is grounded in democratic values rather than epistemic authority alone. This affirms that the crisis of expertise is in essence a crisis of legitimacy: citizens seek not merely reliable knowledge but the assurance that decisions are shaped by shared values and procedural fairness. This echoes König et al.'s (2022) account of the fragmented nature of democratic preferences, which complicates the integration of expertise into governance, as different public's demand different expressions of legitimacy.

Crisis-Resilient Democratic Ecosystems in Science Governance

The analysis also corroborates Fladvad's (2021) and Volacu and Aligica's (2023) accounts of crisis-driven dynamics in democracy. Both observe that crises typically elevate efficiency and speed above deliberation, and the findings show that such conditions reinforce technocratic authority while sidelining citizen participation. This highlights the fragility of democratic norms under pressure and suggests that resilient institutional design must include safeguards for participation even in emergencies. Clayton et al. (2021) adds to this understanding by showing how elite rhetoric can erode democratic norms, and the results suggest that rhetorical fragility interacts with technocratic tendencies to weaken democratic resilience. Maati et al. (2023) show how digitisation exacerbates these dynamics by spreading doubt and polarisation—a finding extended here by demonstrating that participatory innovations need to be robust in digital contexts and resistant to manipulation. The novelty of this context lies in bringing together these fragmented perspectives into a coherent descriptive and normative framework. While Habermas (2022) emphasises structural transformation in the public sphere and Benhabib (2021) foregrounds contestation within the boundaries of politics, this synthesis integrates such theoretical insights with empirical studies in science and technology. The resulting conceptual map highlights persistent tensions between expertise and participation, as well as the practical promise of emerging innovations, such as citizen science, deliberative forums, and hybrid institutional models. Battilana et al. (2022) demonstrate that democratisation within organisations can be achieved through redistributions of power, and a parallel is drawn here for governance: redistributing epistemic authority may enhance both legitimacy and effectiveness. Moe's (2020) notion of "distributed readiness citizenship" also resonates with these findings, since democratic resilience

appears to require citizens who are not merely passive voters but active contributors to the production of knowledge and policy.

The results demonstrate that, while hybrid participatory models are beginning to emerge across diverse democratic contexts, their development remains uneven and frequently fragile—particularly when exposed to the pressures of a crisis. These models, which aim to integrate epistemic authority with citizen engagement, represent a significant departure from traditional dichotomies that juxtapose technocratic governance with populist demands (Boswell & Corbett, 2021; Johnson, 2022; Saikkonen & Christensen, 2022). Nonetheless, their institutionalisation is far from complete. In moments of acute disruption—such as pandemics, climate emergencies, or digital disinformation campaigns—governments often revert to centralised decision-making, sidelining participatory innovations in favour of expediency. This tendency exposes a structural vulnerability within democratic systems: the absence of robust, crisis-resilient mechanisms capable of sustaining deliberative inclusivity under duress. The findings underscore that innovative participatory mechanisms—such as deliberative mini-publics, citizens' assemblies, participatory budgeting, and digital platforms for civic input—can serve as vital supports for democratic resilience. These mechanisms do more than merely supplement representative institutions; they reconfigure the epistemic architecture of governance by embedding pluralistic knowledge sources and normative contestation into decision-making processes. For example, citizens' assemblies on climate policy have demonstrated the capacity to produce informed, legitimate, and publicly acceptable recommendations, even on technically complex and politically contentious issues. Likewise, participatory budgeting initiatives have shown that when citizens are afforded genuine influence over resource allocation, trust in institutions tends to increase, and marginalised voices gain visibility.

However, the transformative potential of these mechanisms is contingent upon their integration into formal political structures and their ability to adapt to evolving socio-political conditions. Fragmented debates—often framed in terms of either enhancing expert authority or expanding citizen participation—fail to capture the systemic interdependencies that underpin democratic resilience. What is required, therefore, is a shift towards integrated inquiry agendas and institutional practises that treat participatory innovation not as a peripheral feature of democracy, but as a foundational element of its adaptive capacity. Such integration necessitates a reimagining of institutional design. It calls for the development of governance architectures that are both epistemically robust and normatively inclusive—structures capable of accommodating expert input without marginalising lay perspectives and remaining responsive even in times of crisis. This may involve embedding deliberative mechanisms within executive agencies, establishing feedback loops between citizen forums and legislative processes, and harnessing digital technologies to scale participation without compromising depth. Crucially, it also demands a cultural shift within institutions: an acknowledgement that legitimacy is not derived solely from procedural compliance or technical competence, but from the capacity to engage citizens meaningfully in shaping collective futures.

Thus, the findings point to a critical juncture in democratic theory and practice. As societies confront increasingly complex and interlinked challenges, the resilience of democratic governance will depend not on privileging either expertise or participation, but on cultivating institutional ecosystems in which both can flourish in dynamic equilibrium. Hybrid participatory models, though still nascent and unevenly institutionalised, offer a constructive pathway towards such ecosystems—provided they are supported by coherent enquiry, sustained political will, and a commitment to democratic renewal. The findings suggest important directions for future research and practice. Hybrid participatory approaches must be institutionalised more systematically, ensuring that they influence core decision-making processes rather than serve as symbolic or peripheral exercises. It is imperative to construct deliberative forums that can operate effectively in crisis situations, to integrate citizen science more directly into governance, and to establish protections against the threats of technocratic hegemony and populist exploitation. Thus, by drawing together insights from political theory, science philosophy, deliberative democracy, and science and technology studies, this paper offers a comprehensive framework for understanding the evolving relationship between science and democracy.

Implications for Contemporary Deliberative Practice

This paper is of direct relevance to professionals involved in facilitating public deliberation and designing participatory governance mechanisms. The findings present a strong directive for policymakers and civil society groups. Participatory structures must not remain limited to superficial consultation. Instead, they must develop into meaningful spaces for public deliberation. Similarly, democratic societies must not only accommodate citizen reasoning and expert testimony in these spaces but also recognise them as equally valuable. This position is substantiated by empirical evidence drawn from the data regarding deliberative mini-publics, particularly in the field of climate governance, where structured facilitation, transparent communication of scientific uncertainty,

and inclusive framing of expert contributions have demonstrably enhanced both the epistemic quality of deliberative outcomes and the perceived legitimacy of resultant policies (Anastasiadou et al., 2021; Chilvers & Kearnes, 2019; Dryzek & Pickering, 2017; Feindt & Weiland, 2018; Kaplan et al., 2021; Krick, 2022; Moore, 2021; Niemeyer et al., 2024; Valkenburg, 2020; Weingart, 2023). These findings have profound implications for nongovernmental organisations (NGOs) and citizen engagement practitioners. The proposed framework can inform the design of participatory initiatives that actively counter technocratic tendencies, particularly during periods of crisis. Embedding mechanisms such as contestation, reflexivity, and co-production within decision-making processes enhances democratic resilience. Such approaches align with the deliberative democratic framework (Dryzek, 2000), participatory governance models (Fung, 2006), and crisis-responsive institutional design (Ansell & Gash, 2008). By fostering inclusive and adaptive structures, these initiatives can uphold democratic integrity while navigating complex and volatile policy environments. It is crucial that democratic societies adequately resource, legally enshrine, and institutionally embed hybrid participatory models. In the absence of such support, these models risk remaining peripheral, confined to ad hoc experiments or short-lived pilot schemes with limited influence on mainstream governance.

The results also lend empirical support to the paper's central hypotheses. Empirical evidence supports the first hypothesis—that integrating scientific expertise into democratic institutions is both essential and inherently problematic. Studies indicate that technocratic reliance on expert authority often sidelines citizen participation, especially during emergencies when urgency tends to override deliberative norms (Bohman, 2004; Fladvad, 2021). In such contexts, participatory initiatives must embed mechanisms of contestation, reflexivity, and co-production to preserve democratic integrity. These design features enable institutions to remain inclusive and accountable while navigating complex policy environments. The second hypothesis—that democratic resilience depends upon a dynamic equilibrium between epistemic authority and civic legitimacy—is reinforced by data showing that effective governance requires transparent institutional mediation that accords value to both scientific knowledge and public reasoning. The third hypothesis—that participatory innovations offer a means of reconciling expertise with inclusion—is partially validated. Mechanisms such as citizens' assemblies, deliberative mini-publics, and co-regulatory bodies have increasingly been recognised for their capacity to enhance both epistemic rigour and democratic legitimacy within contemporary governance frameworks (Anastasiadou et al., 2021; Dryzek & Pickering, 2017; Feindt & Weiland, 2018; Kaplan et al., 2021; Krick, 2022; König et al., 2022; Moe, 2020; Moore, 2021; Niemeyer et al., 2024; Valkenburg, 2020; Weingart, 2023). These participatory innovations offer structured spaces for inclusive deliberation, enabling diverse publics to engage meaningfully with complex policy issues and scientific expertise. However, despite their normative appeal and empirical success in isolated contexts, their institutionalisation remains uneven, often relegating them to the periphery of formal decision-making structures. This marginalisation is indicative of broader tensions between technocratic governance and democratic participation, particularly in an era marked by epistemic uncertainty, political polarisation, and ecological crises. As Habermas (2022) argues, the structural transformation of the public sphere necessitates new modalities of civic engagement that can mediate between expert knowledge and lay perspectives without undermining democratic norms.

The erosion of trust in institutions and the rise of elite-driven rhetoric further underscore the urgency of embedding participatory mechanisms within the core architecture of democratic governance Moreover, deliberative and associative models of democracy—rooted in pragmatist and communicative traditions—offer conceptual tools for rethinking the role of publics in shaping policy and scientific discourse. Hence this paper frames democracy not merely as a procedural arrangement but as an evolving ethos of collective problem-solving, responsive to the indirect consequences of human transactions. Such a perspective aligns with calls for distributed readiness and civic reflexivity, particularly in the face of complex issues such as climate change and democratic backsliding (Moe, 2020; Maati et al., 2023). Importantly, the integration of participatory innovation must be more than symbolic. It requires institutional redesign that accommodates plural epistemologies, fosters civic empowerment, and ensures accountability across scales of governance. This entails moving beyond tokenistic consultation toward embedded deliberative infrastructure capable of sustaining democratic resilience under conditions of complexity and contestation. Thus, the uneven institutionalisation of participatory mechanisms reflects a critical gap in democratic discourse and practice. Bridging this gap is not a matter of preference but of necessity. To safeguard democratic integrity and responsiveness in the twenty-first century, participatory innovation must be systematically integrated into the design and operation of governance institutions. Only then can democratic systems remain resilient, inclusive, and epistemically sound in the face of contemporary challenges.

6. Conclusions

This paper has undertaken a systematic exploration of the intricate interplay between scientific knowledge and democratic governance, with particular attention to the roles and responsibilities shared among citizens, institutions, and experts. Drawing upon a qualitative synthesis of scholarly literature spanning two decades (2004–2024), the analysis yields several pivotal insights into this multifaceted relationship. Firstly, scientific expertise emerges not as an optional asset but as a foundational pillar of sound policymaking—especially in an age marked by global interdependence and complex societal challenges. Secondly, although citizen involvement is widely upheld as a cornerstone of democratic legitimacy, their substantive and epistemic contributions to science-policy dialogues are frequently sidelined or insufficiently harnessed. Thirdly, the capacity of democratic systems to withstand crises appears closely tied to their ability to maintain a dynamic equilibrium between the authoritative knowledge of experts and the participatory legitimacy conferred by the public. Moreover, the paper highlights the possibility of using hybrid governance mechanisms—such as deliberative assemblies and citizen science projects—to bridge these competing imperatives. While promising, such models remain nascent and have yet to be fully embedded within institutional frameworks.

This paper points out the revolutionary value of participatory epistemologies in recalibrating the science-democracy nexus. For example, citizen science initiatives have yielded measurable improvements in environmental monitoring, epidemiological surveillance, and urban planning—not merely as data-gathering exercises, but as platforms for civic empowerment and epistemic pluralism. Deliberative mini-publics have demonstrated that lay participants—when afforded structured engagement and expert facilitation—can generate policy recommendations that rival those of traditional advisory bodies in both coherence and legitimacy. These mechanisms challenge the conventional monopoly of scientific authority by embedding reflexivity, contestation, and value-based reasoning within the advisory process. Moreover, digital platforms for participatory foresight and scenario planning are emerging as scalable tools for integrating diverse knowledge systems, particularly in contexts marked by high uncertainty and contested risk. Such innovations suggest that democratic governance need not dilute scientific rigour; rather, it can enhance it by situating expertise within broader deliberative ecosystems. The institutionalisation of these models, however, demands robust safeguards against tokenism, elite capture, and epistemic injustice. Embedding participatory mechanisms within formal advisory architectures thus constitutes not merely a procedural reform but a normative reimagining of how societies negotiate truth, trust, and power.

The academic and practical contributions of this inquiry are twofold. Conceptually, it offers an integrated framework that reconciles fragmented disciplinary perspectives, fostering a more holistic understanding of how science and democracy co-evolve. Rather than framing the relationship as inherently adversarial, the paper advances a comprehensive depiction of mutual adaptation and interaction. Practically, the findings provide actionable guidance for policymakers and institutional architects charged with designing advisory structures. The paper points to participatory innovations as fertile ground for reform, advocating for a shift away from one-way communication from experts to lay audiences It also emphasises the importance of being open about normative assumptions and inherent uncertainties that shape scientific advice. Nonetheless, it is important to acknowledge that the conclusions may reflect certain biases inherent in the selected body of literature. Although the review process was methodical, it was not exhaustive and may have omitted relevant contributions. Future investigations could benefit from comparative empirical analyses of advisory systems across diverse national and regional contexts to assess the generalisability of these findings. Additionally, further research into the challenges posed by digital engagement and the proliferation of misinformation is essential for understanding how contemporary media environments influence public confidence in both scientific and democratic institutions. Longitudinal studies tracking shifts in public trust in response to expert recommendations and democratic procedures would also provide valuable tips for constructing more resilient governance models. In a world increasingly shaped by scientific intricacy and political division, democratic systems must balance reliance on expert authority with the pursuit of inclusivity. Bridging the gap between empirical realities and normative aspirations demands deliberate institutional innovation—one that democratises expertise without compromising the objectivity and integrity of scientific practice.

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