European Journal of Risk Regulation (2023), **14**, 429–434
doi:10.1017/err.2023.74

CAMBRIDGE UNIVERSITY PRESS

SYMPOSIUM ON CLIMATE, AI & QUANTUM

Climate, AI & Quantum: Europe's Regulatory Horizon

Elif Kiesow Cortez

Stanford University, Stanford, CA, USA
Email: elifkiesowcortez@gmail.com

This symposium sets out to scan the horizon for the foremost dual-use technologies, quantum and artificial intelligence (AI), with transformative and even disruptive potential for social and economic affairs. The symposium intends to encourage a debate regarding possible regulatory and policy responses that might channel development and adoption in a way that responsibly balances benefits and risks. The symposium will also refer to the discussion on how these deep technologies interact with or relate to the climate change challenge currently confronting humanity.

Risks and opportunities stemming from the development and deployment of new technologies might be fruitfully analysed and addressed from an anticipatory governance perspective. The aim of this symposium is to shed light on the regulatory horizon, with contributions reflecting the latest transatlantic scholarly and policy debates on the breakthrough technological developments in the climate, AI and quantum technology domains.

The symposium is also particularly relevant given the ongoing debate on the societal impacts of novel technological breakthroughs, in which a recent volume argues that the direction of technological change is not foreordained, but instead that public actors and institutions can shape the path of technological development and deployment in a manner that spreads the benefits of innovation more broadly across society.[1]

This motivated the symposium, which is centred on the issues and challenges on the regulatory horizon that can arise with the advent and increasingly broad-based commercialisation of quantum and AI, as well as on the links between these and the theme of confronting climate change. Additionally, both quantum and AI are technological innovations that might play a fundamental role in averting perilous levels of climate change. For this to play out constructively and in a desired fashion, the carbon footprint of these technologies needs to be closely monitored and minimised, whereas a comprehensive policy strategy might also include nudges that encourage research and development in quantum and AI applications with the greatest potential to contribute to decarbonisation efforts. For a twin transition – consisting of a simultaneous digitalisation push bundled together with an effective green transformation – to succeed in practice, public policy might need to be proactively steering the direction of technological change in the AI and quantum domains towards the net-zero goal.

Recent developments in the European Union (EU) regulatory and policy space also included attention to the subjects of this symposium. Some examples of these

[1] D Acemoglu and S Johnson, *Power and Progress: Our Thousand-Year Struggle Over Technology and Prosperity* (New York, PublicAffairs 2023).

developments include the European Green Deal,[2] focusing on regulatory efforts to, for instance, promote clean energy and to increase the sustainability of industry, among multiple others.[3] On the disruptive technologies front, one should mention the EU AI Act, which aims to establish a risk-based framework for regulating AI and also ascertains extraterritorial reach. Given the estimated importance of quantum technology as a promising field, it is possible to observe strong interest in promoting the technology, such as via large-scale dedicated investments, which at the EU level stand at around USD 1.1 billion.[4] Furthermore, a European-level effort was undertaken to establish the broadly scoped Quantum Flagship programme that aims to foster the development and deployment of quantum technologies in the EU on multiple levels and via numerous initiatives.[5] There have been other relevant policy developments on the European side, such as Spain launching the first AI enforcement agency[6] and the EU striving to be a competitive player internationally with respect to quantum technologies, in light of the sensitive nature and competitive advantage connected to some of the breakthroughs and advances expected in the quantum domain.[7]

There are also various examples from the European policy discourse in which links are drawn between digitalisation or technological advances such as AI on the one hand and the green transition on the other.[8] In policy briefs and reports, references are made to the concept of a "twin transition", whereby the blue (digital) and green (sustainability) transitions can and should be aligned or jointly accomplished with an appropriate policy strategy. Further indication of this suggested linkage between "blue" and "green" can be also found in the EU Coordinated Plan on Artificial Intelligence,[9] most recently updated in 2021, which is the second main pillar of the EU's AI policy alongside the EU AI Act.[10] The Coordinated Plan on Artificial Intelligence includes many elements focusing on climate and sustainability, as evidenced by how it assigns a sustainability focus to three of the seven sectoral action areas, which delineate supportive measures. The three relevant sectoral action areas of the Coordinated Plan associating AI with green goals comprise the following: "bring AI into play for climate and environment", "make mobility smarter, safer and more sustainable through AI" and "support AI for sustainable agriculture". Relatedly, a recent scholarly contribution provides a comprehensive overview of how machine

[2] European Commission, "A European Green Deal" (14 July 2021) https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (last accessed 18 September 2023).

[3] The Inflation Reduction Act (IRA) in the USA is also a related policy programme of significant scale and ambition aiming to pursue climate policy and sustainability objectives.

[4] M Kaur, "Overview of Quantum Initiatives Worldwide 2023" (*Qureca*, 19 July 2023) https://qureca.com/overview-of-quantum-initiatives-worldwide-2023/ (last accessed 18 September 2023).

[5] E Gibney, "Europe Plans Giant Billion-Euro Quantum Technologies Project" (2016) 532 Nature 426; Quantum Flagship, "Introduction to the Quantum Flagship" https://qt.eu/ (last accessed 18 September 2023).

[6] Real Decreto 729/2023, de 22 de agosto, por el que se aprueba el Estatuto de la Agencia Española de Supervisión de Inteligencia Artificial 2023 122289.

[7] European Commission, "Quantum Technologies Flagship" (30 June 2023) https://digital-strategy.ec.europa.eu/en/policies/quantum-technologies-flagship (last accessed 19 September 2023).

[8] European Commission, "Green Digital Sector – Shaping Europe's Digital Future" (24 May 2023) https://digital-strategy.ec.europa.eu/en/policies/green-digital (last accessed 18 September 2023); European Commission, "European Green Digital Coalition – Shaping Europe's Digital Future" (24 May 2023) https://digital-strategy.ec.europa.eu/en/policies/european-green-digital-coalition (last accessed 18 September 2023).

[9] European Commission, "Coordinated Plan on Artificial Intelligence 2021 Review" (21 April 2021) https://digital-strategy.ec.europa.eu/en/library/coordinated-plan-artificial-intelligence-2021-review (last accessed 18 September 2023).

[10] Whereas the EU AI Act is the regulatory framework for addressing risks stemming from AI, the Coordinated Plan contains pro-innovation policies aiming to make Europe one of the major international players and an attractive region for AI development. Thus, the European strategy towards AI attempts to strike a balance between regulation and innovation.

learning can be deployed as a tool in reducing greenhouse gas emissions and helping with adaptation against climate change.[11]

Additionally, besides AI, experts and commentators have also suggested that quantum technology might be another important lever in achieving sustainability and climate objectives.[12] For instance, quantum computing could play an increasingly important role in optimising processes helping to economise resource use. In the future, it could aid in scientific discovery, such as that related to materials research, and it could also, for example, facilitate the invention of new forms of environmentally friendly fertiliser production, reduce energy needs per achieved computing performance, help optimise renewable energy systems and improve climate modelling, among countless other potential applications. However, it should be noted that it is not yet known over what timeframe exactly the relevant quantum technology capabilities will mature sufficiently to be deployed for some of these mentioned purposes. In addition, importantly, scholars have called for the development of a reliable approach and methodology to assess the environmental footprint generated by frontier technologies such AI and quantum themselves, with work on AI on this matter already occurring.[13] In sum, the EU is attempting to connect deep technology development to climate polices, as evident in elements of the European Green Deal policy package and the relevant placement of sustainability-related goals within its AI policies. A joint report by the European Investment Bank and the European Commission stresses the future potential of quantum technology for tackling climate change and for contributing to the realisation of the ambitious goals laid out in the European Green Deal, such as making the EU carbon-neutral by 2050.[14]

Meanwhile, across the Atlantic, the National Institute of Standards and Technology (NIST) AI Risk Management Framework[15] might be seen as among the key efforts to set up relevant rules and guardrails. Additionally, the AI Bill of Rights,[16] a set of voluntary guidelines, was published by the Biden administration in October 2022, and additionally the US Algorithmic Accountability Act[17] (US AAA) was put forward within Congress, but the prospects for its adoption are uncertain at this point. In 2023, efforts were made by the Biden administration to convene meetings with representatives of large technology firms to develop a set of commonly agreed-upon best practices for AI research, outlining standards for safety, security and trust to be followed on a voluntary basis by AI firms.[18]

[11] D Rolnick et al, "Tackling Climate Change with Machine Learning" (2022) 55 ACM Computing Surveys 42.

[12] P Cooper et al, "Quantum Computing Just Might Save the Planet" (*McKinsey & Company*, 2022) https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/quantum-computing-just-might-save-the-planet (last accessed 8 May 2023).

[13] LH Kaack et al, "Aligning Artificial Intelligence with Climate Change Mitigation" (2022) 12 Nature Climate Change 518.

[14] European Investment Bank and European Commission, "A Quantum Leap in Finance: How to Boost Europe's Quantum Technology Industry" (2023) https://www.eib.org/attachments/lucalli/20220112_a_quantum_leap_in_finance_en.pdf (last accessed 23 October 2023).

[15] NIST, "AI Risk Management Framework" (12 July 2021) https://www.nist.gov/itl/ai-risk-management-framework (last accessed 18 September 2023).

[16] The White House, "Blueprint for an AI Bill of Rights" (October 2022) https://www.whitehouse.gov/ostp/ai-bill-of-rights/ (last accessed 18 September 2023).

[17] CS Morgan, F Langlois and J Lan, "U.S. House and Senate Reintroduce the Algorithmic Accountability Act Intended to Regulate AI" (*Lexology*, 8 April 2022) https://www.lexology.com/library/detail.aspx?g=c9bfbfca-a88e-4fd9-b556-d903a4cf0bd7 (last accessed 14 December 2022).

[18] The White House, "FACT SHEET: Biden–Harris Administration Secures Voluntary Commitments from Leading Artificial Intelligence Companies to Manage the Risks Posed by AI" (21 July 2023) https://www.whitehouse.gov/briefing-room/statements-releases/2023/07/21/fact-sheet-biden-harris-administration-secures-voluntary-commitments-from-leading-artificial-intelligence-companies-to-manage-the-risks-posed-by-ai/ (last accessed 18 September 2023).

In the process of quantum technologies reaching greater maturity levels over the coming years, analogous discussions about the potential societal impacts and ethical aspects of quantum technologies are likely to emerge and, in this case, given the breadth of quantum technologies, possibly inviting analysis of such impacts on a use-case basis.[19]

Certainly, the quest for advancing dual-use technologies also contains a geopolitical dimension, especially in times of heightened geopolitical uncertainty and tension. A reflection of this can be found in the Biden Executive Order from 9 August 2023, which was an addition to the US outbound investment control regime, in this case specifically outlining controls on outbound US investments in three technology sectors in China, namely semiconductors, quantum information technologies and AI.[20] Whereas Members of Congress defending a stricter foreign policy approach were advocating for broader controls on these types of investments spanning more domains, Biden's Executive Order might be interpreted as more balanced and targeted as it prioritised restrictions aimed at sensitive technologies that are critical to a country's military, intelligence, surveillance or cyber-related capabilities.[21] On 3 October 2023, the European Commission announced that it would start collective risk assessments together with Member States initially on four areas, namely (1) advanced semiconductor technologies, (2) technologies related to AI, (3) quantum technologies and finally (4) biotechnologies. This then could result in restrictive measures such as export controls or also promoting activities for these technologies in the future.[22]

The Inflation Reduction Act (IRA) in the USA is also a policy programme of significant scale and ambition that likewise is geared towards pursuing climate policy and sustainability objectives, such as by sparking a clean energy industrial revolution.[23] Another development in the USA concerns the Department of Energy publicly announcing that investing in quantum sensing research is among the priorities in terms of future innovation potential.[24]

Hence, it might be expected that further regulatory and policy challenges as well as opportunities for collaboration at the intersections of climate, AI and quantum technologies loom on the horizon for policymakers and the stakeholder community, including and especially for the responsible actors shaping US–EU collaboration on these vital and future-defining subjects. We hope that the selected articles in this symposium provide an introduction to certain domains and dimensions of this upcoming discussion.

Forecasting the trajectories of technology-induced transformations involves significant uncertainty, which calls for the type of interdisciplinary analysis undertaken for this

[19] E Kiesow Cortez et al, "A Quantum Policy and Ethics Roadmap" (11 July 2023) https://papers.ssrn.com/abstract=4507090 (last accessed 18 September 2023).

[20] The White House, "Executive Order on Addressing United States Investments in Certain National Security Technologies and Products in Countries of Concern" (9 August 2023) https://www.whitehouse.gov/briefing-room/presidential-actions/2023/08/09/executive-order-on-addressing-united-states-investments-in-certain-national-security-technologies-and-products-in-countries-of-concern/ (last accessed 18 September 2023); N Berman, "President Biden Has Banned Some U.S. Investment in China. Here's What to Know" (*Council on Foreign Relations*, 29 August 2023) https://www.cfr.org/in-brief/president-biden-has-banned-some-us-investment-china-heres-what-know (last accessed 18 September 2023).

[21] K Klyman, "Biden Takes Measured Approach on China Investment Controls" (*Foreign Policy*, 19 August 2023) https://foreignpolicy.com/2023/08/19/biden-approach-china-economy-investment-control/ (last accessed 18 September 2023).

[22] European Commission, "Commission Recommendation of 3 October 2023 on Critical Technology Areas for the EU's Economic Security for Further Risk Assessment with Member States" (2023) https://defence-industry-space.ec.europa.eu/system/files/2023-10/C_2023_6689_1_EN_ACT_part1_v8.pdf (last accessed 13 October 2023).

[23] J Bistline et al, "Emissions and Energy Impacts of the Inflation Reduction Act" (2023) 380 Science 1324.

[24] M Swayne, "Quantum Sensing Is a U.S. Department of Energy Priority" (*The Quantum Insider*, 10 April 2023) https://thequantuminsider.com/2023/04/10/quantum-sensing-is-a-u-s-department-of-energy-priority/ (last accessed 18 September 2023).

symposium. At the same time, for potentially disruptive technologies to live up to their full potential while minimising adjacent risks, it seems useful to draw up a well-thought-out framework of rules in advance. Hence, contributions to this symposium analyse select regulatory efforts directed at managing potential socioeconomic and climate-related impacts and risks linked to some of these emerging technologies. Given the complexity of climate, AI and quantum technologies, the interdisciplinary scholarly approaches in this symposium uniquely study the projected repercussions of these domains in order to be leveraged for informing current and future policy debates.

The contributions to this symposium cover governance structures under discussion in these respective regions, pointing out the potential for synergies where appropriate.

The contribution by Bötticher et al introduces a novel research programme termed the "quantum humanities".[25] It would not only include the application of quantum algorithms to humanities and social science research, but also a reflection on the methods and techniques of quantum computing, in addition to an evaluation of its potential societal implications. The authors aim to delineate the contours of the proposed field of quantum humanities and to establish it as a meaningful and integral part of the humanities and social sciences. The article suggests pursuing collaboration and dialogue between researchers from different disciplines to develop a deeper comprehension of the potential of quantum computing to advance our understanding of the world. The authors further propose four core elements of the emerging field: first, applying quantum computing to explore humanities questions; second, identifying the technology's societal implications; third, reflecting on how knowledge generation is impacted by quantum technologies; and lastly, investigating the broader context in which the development of quantum technologies takes place.

Kiesow Cortez and Maslej zoom in on specific cases of AI-related disputes and their adjudication, covering cases from both the USA and Europe.[26] Before doing so, the authors provide an overview of recent regulatory and policy developments in the USA and the EU concerning AI. The authors go on to discuss cases and disputes that arose in which AI was used to automate elements of social benefits provision, social media recommender systems, large-scale web scraping related to a facial recognition system made available to law enforcement, customer emotion recognition and a tool for assisting with judicial parole decisions. AI has already started to be utilised in varied domains and will increasingly affect multiple spheres of life in the near future, and evidently judicial and administrative institutions are already offering rulings on AI-related disputes. This article reports on the status quo on a selection of such rulings in the USA and Europe in order to shed light on how different legal systems are accommodating an emerging technology with disruptive potential. This exercise sheds light on which type of legal challenges can be expected when it comes to deploying automated systems in these jurisdictions and exhibits a variety of exemplary legal risks for prospective actors or organisations seeking to develop and deploy AI.

The contribution by Liman and Weber traces back and discusses the evolving policy discourse in Europe and the USA on quantum technologies and how they reflect, in some respects, diverging underlying priorities on each side of the northern Atlantic.[27] The authors distil how policy and institutional actors in European countries came to frame their approach to fomenting quantum computing by relying on the concept of "digital

[25] A Bötticher, J Hernandez, MC Ketteman, V Gast and R Araiza Bravo, "Introducing a Research Program for Quantum Humanities – Theoretical Implications" (this issue) European Journal of Risk Regulation.

[26] E Kiesow Cortez and N Maslej, "Adjudication of Artificial Intelligence and Automated Decision-Making Cases in Europe and the USA" (this issue) European Journal of Risk Regulation.

[27] A Liman and K Weber, "Quantum Computing: Bridging the National Security–Digital Sovereignty Divide" (this issue) European Journal of Risk Regulation.

sovereignty", whereas the US approach towards this technology more strongly references "national security" as an essential concern. Despite the different framings, the authors point towards other cases of successful international scientific collaboration and highlight how accentuating shared visions could help to bridge the national security and digital sovereignty divide. The advised policy strategy would not overemphasise either "digital sovereignty" or "national security", but rather would bring to the fore interests shared across both concepts, with a view to promoting international collaboration. However, the authors also note that such collaborations are more likely to succeed when they are clearly scoped and focused on a specific goal rather than on a broader set of policy challenges.

Lastly, the article by Cortez discusses the complex linkages between AI and efforts to halt climate change, with a particular emphasis on the effects of AI on democratic governance and participation.[28] The article discusses risks of AI reliance for political processes, but also whether AI-based tools can, under certain conditions, increase opportunities for bottom-up citizen participation. Examples of the latter are being deployed in Taiwan and illustrate possibilities for encouraging participation via innovative digital governance tools. The author further argues that facilitating citizen participation could prove advantageous for increasing the chances of popular buy-in when it comes to enacting and implementing effective and ambitious climate policy at the required pace to avoid high-risk tipping points. Similarly, innovative forms of participation could help to ameliorate a potential dilemma of voice versus speed regarding the green transition. Cortez goes on to address the nexus between digital applications such as AI and climate justice. In a more exploratory manner, the article discusses whether innovative governance methods could invigorate the multi-level global climate regime, such as by facilitating interlinkages and integration between different levels. However, the author also notes that contextual conditions matter, and that an indiscriminate adoption of digital governance arrangements could exacerbate old or even generate new inequalities of access and participation.

These contributions to the symposium analyse selected existing or incipient regulatory efforts directed at managing certain risks linked to these emerging technologies as well as their relationships with the socio-legal environment. Through an anticipatory governance approach, risks and opportunities resulting from the development and application of new technologies can be insightfully examined. Therefore, with contributions that reflect the most recent international scholarly and policy discussions on the groundbreaking technical advancements in the fields of climate, AI and quantum technology, this symposium aims to shed a light on the regulatory horizon pertaining to these themes.

[28] F Cortez, "Artificial Intelligence, Climate Change and Innovative Democratic Governance" (this issue) European Journal of Risk Regulation.

Cite this article: E Kiesow Cortez (2023). "Climate, AI & Quantum: Europe's Regulatory Horizon". *European Journal of Risk Regulation* **14**, 429–434. https://doi.org/10.1017/err.2023.74