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Abstract

This paper examines how quantum computing reshapes International Relations theory through two contrasting theoretical frameworks: liberalism and Marxism. As quantum computing emerges as a transformative technology with profound implications for national security, economic development, global governance, and ethics, existing IR theories must be interrogated for their capacity to account for its consequences. From a liberalist perspective, quantum computing intensifies both cooperative and competitive dynamics among states, manifesting in an escalating quantum race between the United States and China, while simultaneously generating demand for multilateral governance through institutions such as the World Economic Forum and WIPO. Liberal frameworks prove practical for capturing the role of norm entrepreneurship and intellectual property regimes in shaping state behavior around quantum technologies, though embedded contradictions within IP systems risk deepening global inequalities rather than resolving inequalities of access. The Marxist perspective, by contrast, situates quantum computing within broader structures of capitalist ownership, ideological control, and the exploitation of mental labor, arguing that dominant narratives of technological neutrality and inevitability obscure questions of who controls quantum resources and whose interests they serve. While Marxist scholarship on quantum computing remains comparatively scarce, this paper argues that its critical interrogation of ownership structures provides an indispensable complement to liberal institutional analysis, together offering a more comprehensive theoretical account of quantum computing's emerging role in world politics.

How Quantum Computing Shapes IR Theory: Liberalist Perspective

Liberalism, an International Relations Theory grounded in the assumption of anarchy yet oriented toward global cooperation, is deeply concerned with transformative technologies such as Quantum Computing, which have the potential to reshape statecraft. From a liberal perspective, quantum computing introduces both opportunities and challenges for how states pursue their interests, particularly in areas of national security, economic development, and technological innovation. Liberal global institutions, such as multilateral organizations and intellectual property regimes, reinforce liberalism's position as the dominant school of thought on quantum technology by establishing legal frameworks that govern state behavior regarding new technologies. Despite its economic and scientific potential, debate surrounding the Intellectual Property of quantum computing concerns issues such as inequality of access and hindrance to collective progress. Furthermore, quantum computing introduces significant security risks within the context of a "quantum race," particularly between major, powerful actors such as the United States and China, which can completely reshape the liberal world order.

A quantum advantage in military and technological capabilities can immediately disrupt the balance of power and effectively determine the outcome of the quantum race. A central theme in James Der Derian and Stuart Rollo's article, "Quantum 3.0: What Will It Mean for War, Peace, and World Order?", explores the transformative consequences of quantum technology superiority in reshaping the foundations of global politics from a liberal perspective. To demonstrate the superiority of quantum computers, the article states, "[In 2020] China's University of Science and Technology claimed the holy grail of 'quantum advantage' (solving real-world problems faster than a classical computer) with its 66-qubit Zuchongzhi [quantum]

computer, performing calculations in 20 seconds that would take a [classic] supercomputer 600 million years" (Der Derian & Rollo, 2). Clearly, such technical capabilities can have devastating civilian and military implications. Quantum computing threatens the very foundation of current economic, military, and security encryptions, the article explains, "[quantum computers] confer a major security advantage in the realm of cyberattacks to both civilian and military infrastructure. A quantum attack would compromise the security of the entire network of a rival [country]'s digital commerce and communications if it remained operating on classical encryption standards"(Der Derian & Rollo, 4). The day quantum advantage is achieved by a nation, and when the cryptographic and security foundations of the digital world fall under attack, is known as Q-Day, a prophesied moment of global vulnerability. This eventuality has led powerful actors such as China and the United States to invest heavily in the quantum race. The authors, Der Derian and Rollo, write, "between 2015 and 2023, China's investment into quantum technology grew from US$200 million to US$15.3 billion, a rate of almost 8,000 percent in eight years"(Der Derian & Rollo, 7). Although the United States has lost the lead in quantum spending (US$8.4 billion), its private industry still leads the world's private market in quantum technology investment. This escalating competition underscores that quantum computing is no longer merely a technological breakthrough but a core national security priority reshaping the balance of power in the emerging world order. As a result, the pursuit of quantum advantage transforms national security into a technologically driven competition, where states must balance cooperation and conflict while safeguarding their economic systems, digital and military capabilities.

Although national security remains a central concern within liberalism, it is not viewed as a zero-sum competition between states. Instead, liberalism emphasizes cooperation, international

institutions, and shared norms as mechanisms to promote interdependence and global stability. Within this framework, liberalist discussions surrounding quantum computing highlight the role of rules-based systems and institutions in shaping global outcomes. In his article, "Canada as a Norm Entrepreneur in Quantum Science and Technology", Michael P.A. Murphy examines how Canada can leverage its unique position to take a leading role in shaping quantum governance within liberal institutions, despite the growing fragility of the liberal international order amidst U.S. isolationism. Murphy suggests, "Canada could serve its national interest and also raise its prestige and influence on the world stage by supporting the development of new international norms [on Quantum Science & Technology]"(Murphy, 1). The quantum race is not only a technical race, but also a geopolitical opportunity, allowing less dominant countries to solidify and strengthen their presence in the new emerging world order. Through "norm entrepreneurship", states can promote new standards, values, and lead governance frameworks for quantum technologies, to ensure ethical development and use of quantum computers globally. Murphy writes, "Canada holds the G7 chair and can place quantum [Science & Technology] regulation as a central agenda item… Instead of leaving quantum S&T conversations to take place within domestic contexts, incorporating discussions around quantum S&T policy on the agenda of international institutions will help promote the norm of international collaboration for ethical use of these powerful technologies"(Murphy, 8). Evidently, given the opportunities and risks presented by quantum computing, international cooperation, governance, and the ethical use of quantum computers remain central to discussions within the theory of liberalism.

Liberal institutions further address ethical and moral concerns, such as intellectual property rights, by regulating economic and technological development to balance the "tragedy

of the commons" and the "tragedy of the anticommons". In doing so, they promote fair competition and access while protecting innovators, incentivizing creativity, and ensuring economic growth. In the "Quantum Computing Governance Principles" published by the World Economic Forum, it is reported, "as a global forum for political, economic, social, and technological stakeholders, [WEF] is positioned to draft such principles. Quantum computing is sufficiently advanced for us to have an idea of … what kind of impact it will have. And the technology is not yet so advanced that such principles can only be retroactive"(Coates et al. 2022, 5). Liberal global organizations, like the World Intellectual Property Organization (WIPO), established under the World Trade Organization, are designed to uphold such principles, balancing the interests of political, economic, technological, and social stakeholders while reinforcing the norms and values of the liberal international order. Quantum Computing hardware, software, algorithms, and facilities are protected under Intellectual Property Rights (IPR), and Intellectual Property (IP) regimes can incentivise innovation through the protection of intellectual property; though, at the same time, they can create anticompetitive barriers for the commons. Mauritz Kop et al., in their article "Intellectual Property in Quantum Computing," published in the Journal of Intellectual Property Law, argue, "The USPTO has granted 91.22 per cent of the patents. Over the last 20 years [2001-2021], the EPO has only granted 166 patents… Notably, the Chinese patent office has recently surpassed the EPO in the number of quantum computing patents [in 2021]"(Kop et al., 10). In other words, the United States Patent and Trademark Office (USPTO), dominates the intellectual property patent scene compared to Europe and China. Furthermore, Kop et al. state, "Our results show that IBM (USA), D-Wave (Canada) and Northrop Grumman (USA) currently have the largest patent portfolios in quantum computing"(Kop et al., 11). This indicates a clear concentration of market power in the hands of

American corporations. Although global intellectual property institutions aim to reward first movers, excessive, long-term protection can hinder the advancement of quantum computing and restrict access for start-ups, developing countries, and the broader scientific commons.

How Quantum Computing Shapes IR Theory: Marxist Perspective

Marxist scholarly literature on Quantum Computing, although scarce, exists as a less dominant school of thought. Fetishization of scientific breakthroughs and mystification of quantum computers hardly leave any space for critical thought, examination of the historical materialism of quantum technology, critique of ownership structures, and exploration of the dialectical logic of quantum computers, or lack thereof. Viktor Suter et al.'s cross-domain analysis of more than 2,200 documents, over 23 years (2001-2024), demonstrates how limited critical or Marxist discussions are within the broader discourse on quantum technologies. In their "Narratives on quantum technologies: a cross-domain analysis of media, business, and policy discourses", they find, "Government texts give overwhelming attention to 'National Tech Strategies' (39.6%) and 'Technical Aspects & Applications' (37.8%). Other themes, such as 'Business & Market Development' (13.1%), 'People & Society' (8.6%), and 'Politics & Global Conflicts' (1.0%), receive less emphasis" (Suter et al., 11). Suter et al. suggest the overwhelming framing of quantum technology as a "quantum race" can become a self-fulfilling prophecy, where ethical and moral considerations are pushed to the margins. Guglielmo Carchedi writes, "These [technological] developments pose new theoretical problems which, if left unaddressed, will undermine Marxism's relevance as a revolutionary theory of modern capitalism" (Carchedi, 2). Therefore, a Marxist approach to quantum computing ought to move beyond the language of innovation and examine the deeper structures shaping it, such as global inequality, ideological control, and capital ownership.

The early shaping of narratives around quantum computing provides a unique opportunity to establish a historical materialist understanding of quantum technology before its reification further deepens global inequality. María A. Barea's article, "Quantum for Whom? Situating Ethical Risks in Quantum Technologies' Innovation Context", offers an interdisciplinary view of quantum computing, urging the upstream integration of ethical considerations in the broader socio-technical dynamics of quantum tech. Barea highlights that the mystification of quantum computers, accompanied by rhetoric such as quantum supremacy, create a "culture of overhype" that deepens global inequality. She states, "As public discourse becomes shaped by mystique or exaggerated expectations, an epistemic asymmetry is introduced which risks reinforcing power imbalances between expert communities and the broader public … [hype and mystification] not only distort expectations but narrow public deliberation, entrench asymmetries, and divert ethical inquiry from urgent issues" (Barea, 7). For instance, quantum technology is said to revolutionize environmental sustainability, with scientists imagining future quantum computers that could simulate complex biological systems and climate models, at a scale classical computers cannot easily achieve. Sustainability narratives have already shaped, even though this field is too fallow to produce real breakthroughs. Barea writes, "World Economic Forum highlights QT for carbon capture, energy transitions, and climate mitigation… [though] In quantum computing, sustainability concerns are further complicated by the cryogenic cooling requirements of superconducting qubit systems and the material intensity of dilution refrigerators, which challenge claims of net environmental benefit at scale" (Barea, 6). Devices meant to advance environmental sustainability outweigh their own benefits due to the ecological burden required to produce, cool, and maintain them. Moreover, Barea extends this concern into the areas of security, privacy, and surveillance, where quantum technologies intensify existing

power inequalities. Barea states, “Quantum computing may decrypt communications, financial, health, and governmental data. Meanwhile, quantum key distribution (QKD) may radically enhance cryptography, creating a paradox where QT both undermines and reinforces privacy” (Barea, 7). In other words, the global north, governments, and major corporations may gain access to stronger protection and greater surveillance capacity through the centralization of quantum computing resources, while ordinary people become more vulnerable to data extraction, monitoring, and classification. Underscoring the significance of Barea’s call to examine quantum ethics at the early stages of innovation. Before dominant narratives become fixed, critical thinkers ought to question who controls the technology, whose interests it serves, and what unequal futures it may produce. The early formation of quantum narratives allows for a correct historical materialist understanding of quantum technology before it becomes reified as neutral or inevitable progress. From a Marxist perspective, therefore, quantum computing is not a neutral technological advancement, but a subject of questions of ownership, control, and unequal informational power.

The mystification of knowledge obscures its material basis in human labor and reinforces capitalist relations of exploitation and control. Cardechi, in his article, “Beating the Untrodden Paths: Computers, Artificial Intelligence and Quanta in Marxist Theory”, extends Marx's analysis of the labour process to what he calls the mental labour process, arguing that there is no such thing as immaterial labour and that knowledge itself is material, “the cognitive process is a process of change in the nervous system, in the interconnections of neurons in the human brain... If synapses are material, then their effects are material too, and so must be knowledge as the outcome of such interconnections and effects. Therefore, knowledge is material even if

intangible" (Cardechi, 3). Although diverging from Lenin's traditional view of knowledge as immaterial, for Carchedi, knowledge is material because it is the product of the mental labor process, meaning that thinking, theorizing, programming, scientific research, and mathematical abstraction are not separate from labor, but are forms of labor themselves. This is coherent with the current framing of intellectual property as a form of material value, with a stark difference that, while IP, by commodifying knowledge, makes it ownable, Carchedi shows knowledge can create surplus value, and the work of scientists, programmers, and theorists can be exploited. Hence, he claims, AI does not produce new knowledge because it only recombines already existing information through formal logic and probability. In fact, AI deteriorates when it is trained only on its own outputs, unless it is continuously supplied with new human-produced data. Carchedi then extends this argument to quantum computers, explaining that even quantum computers, or AIs empowered by quantum computers, cannot produce new knowledge because they remain bound to pre-deterministic formal logic and cannot engage in open-ended dialectical thinking processes. In contrast, humans possess a "reservoir of formless potentials", intuition, and "class-determined understanding of right or wrong", which give meaning to the mental labor process. Cardechi states, "The belief that computers are capable of emulating human thought is not only wrong, it is also a pro-capitalist ideology because of its blindness to the class content of the knowledge that is stored in human labour power, which is thus revealing of its incapacity to grasp the contradictions that are inherent to the generation of knowledge" (Cardechi, 17). Reaching the crux of his argument, Cardechi critiques the mystification and irrationalisation of quantum computers, more specifically, the Copenhagen Interpretation (CI) of quantum mechanics and the concept of superposition, a state of a quantum qubit, where it is neither a one nor a zero, until observed or measured. He writes, "For Marx, there is no [a-temporal] universe

populated by superposed entities, which are neither numbers nor zero, or entities that become realised as a number or zero when they collapse into this world" (Carchedi, 19). He instead replaces superposition with the dialectical concept of potentiality, like flipping a coin, where a coin has the potential to be *heads* or *tails*; the idea is temporal, tangible, material, and free of irrationality or mysteries. Lastly, Carchedi uncovers the origins of irrationalism, a tool serving capitalism. He marks the emergence of the acausal Copenhagen Interpretation during a period of intense class struggle that followed the First World War (1918–1921), he writes, "The Zeitgeist of that time was strongly permeated with irrationalism, which pervaded the consciousness of philosophers and, through this channel, the irrational perceptions of the work of physicists… When the CI was born, irrationalism was a powerful instrument to defend and foster the interests of the capitalist class, whether the physicists were aware of this or not" (Carchedi, 27). Essentially, the mystification of quantum technology "plays into the hands of capitalism" by making the essence of reality appear beyond scientific and social explanation. If workers are to believe that even nature itself is fundamentally irrational, then the capitalist system can also appear as something too complex or mysterious to be transformed. Guglielmo Carchedi contributes to Marxist scholarly discussions by restoring the need for historical materialism, showing that knowledge, even quantum knowledge, has a material basis, a class content, an ideological function under capitalism, and is subject to questions of structural ownership.

Quantum computing is an accelerator of the transformation of capitalism. No doubt, quantum computing has the potential to enhance and revolutionize optimization, machine learning, chemical simulation, and cryptography. Critical and Marxist scholars, however, seek to shed light on the ownership, acquisition, and structures that shape these technologies. Michael A.

Peters and Tina Besley, in their “Critical Philosophy of the Postdigital”, develop a framework for critiquing the postdigital world by examining the “mathematico-technical control systems” of the political economy and the global digital infrastructures. Peters et al. write, “There is little doubt that quantum information science holds for next-generation computing and processing. Most effort has gone into harnessing development at the level of apps for business in the global competitive economy. Little if any thought has gone into the broader philosophy and how quantum information science will fundamentally alter the conditions of society” (Peters et al., 5). One reason for the lack of unionization and philosophical consensus on the effects of quantum computing, is the transformation of value form and persistence of capitalism. When workers struggle to adapt to new forms of automation, data extraction, and algorithmic control just to survive, the deeper social effects of quantum computing become difficult to examine. Peters et al. write, “Algorithmic capitalism and its dominance of the market increasingly across all asset classes has truly arrived. It is an aspect of informationalism (informational capitalism) or ‘cybernetic capitalism,’... systems of the post-industrial capitalist economy in its third phase of development - from mercantilism, industrialism to cybernetics - linking the growth of the multinational info-utilities (e.g., Google, Microsoft, Amazon)” (Peters et al., 10). Peters et al.’s contribution helps frame quantum computing as part of a broader shift in capitalism, new forms of capitalism increasingly reshape labor, ownership structures, and social life. They warn, “In retrospect and from the perspective of an ‘algorithmic capitalism’ in full swing, the welfare state and full employment may seem like a mere historical aberration” (Peters et al., 8). Highlighting why quantum computing must be examined through a Marxist lens, examining its risks to deepen existing inequalities and the production of knowledge that perpetuates ownership structures.

Liberalism, concerned with security, economy, and ethics, through its global institutions and IP regimes that regulate quantum computing, remains the most dominant school on the subject of Quantum Computing, as we live in a liberal world order that continues to shape the rules, norms, and governance frameworks surrounding emerging technologies. The liberalist perspective proves particularly convincing in its ability to account for both the cooperative and competitive dimensions of quantum computing, by recognizing that states can engage in an intensifying quantum race while still pursuing multilateral governance through institutions like the WEF and WIPO. Murphy's framework of norm entrepreneurship further strengthens liberalism's explanatory power, demonstrating that the quantum domain is not exclusively reserved for great power competition, but remains open to institutional leadership and normative influence from middle powers. Liberalist scholars are well aware of embedded contradictions within their own IP regimes, balancing the incentivization of innovation and the promotion of fair competition. Nevertheless, given that international responses to quantum computing continue to be mediated through liberal institutions, international law, and multilateral forums, liberalism remains the most comprehensive and applicable theoretical framework for analyzing how states, markets, and international organizations navigate challenges quantum computing presents to the existing world order.

Marxist scholarship on quantum computing, on the other hand, though operating at the margins of dominant discourse, provides an indispensable critical perspective to the narratives of technological neutrality and inevitability. Across the works of Barea, Carchedi, and Peters and Besley, the critical and Marxist theorists consistently question what mainstream theories obscure. For instance, Carchedi's restoration of the material basis of knowledge demonstrates that the

mental labor of scientists, programmers, and theorists who develop quantum technologies is itself subject to capitalist exploitation, and that the mystification of quantum mechanics through the Copenhagen Interpretation serves an ideological function, making both nature and the capitalist system appear too irrational and complex to be transformed. While Marxist literature on quantum computing remains scarce relative to liberalist scholarship, this scarcity is itself a symptom of the asymmetries that Marxist scholars seek to address. Nevertheless, the Marxist framework remains analytically compelling precisely because it asks the questions other schools of thought avoid, such as who owns quantum computing resources, whose labor produces it, whose interests it serves, and what power structures dominant narratives perpetuate.

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