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TRADE LAW AND INNOVATION IN LDCs: RETHINKING WTO GOVERNANCE AT THE EDGE OF THE INDUSTRY 6.0 ERA

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ABSTRACT

The rapid emergence of Industry 6.0marked by hyper-digitalization, artificial intelligence, quantum computing, and algorithm-driven economies poses profound challenges for the World Trade Organization (WTO) and its legal framework. This article critically examines the capacity of the WTO's core agreements the GATT, GATS, and TRIPS to regulate and adapt to this new industrial paradigm. Employing a doctrinal legal analysis grounded in WTO case law, treaty interpretation, and comparative regulatory developments, combined with interdisciplinary insights into AI, quantum technologies, decentralized manufacturing, and digital trade systems, the study maps the tensions between existing trade norms and technological evolution. The findings demonstrate that the WTO's traditional legal dichotomies goods versus services, human versus non-human inventorship, and national versus global IP enforcement are increasingly untenable in algorithmically coordinated, data-driven economies. Core agreements lack provisions on digital product classification, cross-border data governance, AI-generated intellectual property, and algorithmic regulation, exposing critical doctrinal gaps and institutional blind spots. The novelty of this study lies in being among the first to systematically assess WTO compatibility

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with Industry 6.0 while advancing a multi-tiered reform strategy spanning doctrinal, normative, and institutional dimensions. It reconceptualizes WTO law in light of decentralized, non-human innovation and transnational digital sovereignty. Practically, the article provides actionable recommendations for negotiators and policymakers, including the creation of a Digital Trade Protocol, TRIPS amendments to cover AI and blockchain IP rights, revitalization of the Dispute Settlement Mechanism with technical expertise, and embedding digital development aid for LDCs. The study concludes that bold legal innovation is essential to preserving the WTO's centrality and legitimacy in an era where trade is defined by intangible assets, algorithmic governance, and global digital inequality.

Keywords: *WTO, Industry 6.0, Digital trade, AI-generated IP, Cross-border Data Flows*

INTRODUCTION

The WTO has created by the Marrakesh Agreement in 1994 to serves as the primary global institution overseeing international trade relations.[1]It succeeded the General Agreement on Tariffs and Trade (GATT) established in 1947 by integrating various trade agreements into a unifiedframework. It aims to promote free and fair trade among its member nations.[2]The WTOhas achieved several significant milestones since its establishment. One of its major accomplishments is the creation of a permanent institution to oversee international trade, replacing the provisional nature of the GATT system. Further broadened the scope of the multilateral trading system by incorporating not only trade in goods but also services and intellectual property rights, to address evolving dynamics of global trade.Notable sector-specific agreements, such as the Agreement on Textiles and Clothing and the Agreement on Agriculture,were adopted to address long-standing trade issues in these areas. [3]

Additionally, the WTO strengthened the rules on industrial subsidies by providing greater clarity and meaning to the original GATT provisions, ensuring more disciplined use of subsidies.In areas where GATT rules were previously lacking or insufficiently detailed, the WTO introduced

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1 Richard B Stewart and Michelle Ratton Sanchez Badin, 'The World Trade Organization: Multiple Dimensions of Global Administrative Law' (2011) 9 *International Journal of Constitutional Law* 556.

2 Chidebe Matthew Nwankwo and Collins ChikodiliAjibo, 'Liberalizing Regional Trade Regimes Through AfCFTA: Challenges and Opportunities' (2020) 64 *Journal of African Law* 297.

3 Henok Asmelash, 'The First Ten Years of WTO Jurisprudence on Renewable Energy Support Measures: Has the Dust Settled Yet?' (2022) 21 *World Trade Review* 455.

comprehensive rules covering anti-dumping and countervailing measures, safeguards, customsvaluation, import licensing, and rules of origin,among others. Another landmark achievement is the establishment of dispute settlement system.As of April 2025, the WTOcomprises 163 full members and 25 observer states.While the WTO's comprehensive legal framework has been central to global trade governance, it has been slow to forecast and integrate contemporary concepts like Industry 5.0 and the upcoming Industry 6.0.Asmentioned above, Industry 6.0 represents the next phase of industrial evolution, characterized by smart automation, extensive connectivity, and the integration of human-centered technologies with humanized robotics, quantum computing, AI, and sustainable technological innovations.[4] In one way or another Industry 6.0 aligns closely with key objective of WTO. It effectively reduces trade barriers by facilitating seamless digital integration, thus improving market access while upholding the principles of non-discrimination and fair competition.[5]

Moreover, itim proves compatibility of between tangible goods and product data, thereby directly contributing to transparency and efficiency in trading practices. Furthermore, the emphasis on "antifragile" and flexible manufacturing systems of industry 6.0 aligns with WTO goals of fostering sustainable and resilient trade.[6] Therefore, Industry 6.0 enhancesproductivity, supports inclusive economic growth, and ensurestechnological advancements. As mentioned above, the shift towards Industry 6.0 will positively impacts production costs, enhances product quality, and broadens consumer choices, aligning with the WTO's vision of, fair, free, and efficient global trade. However, despite these pros, it will also bring several negative impacts across essential concerns of WTO. It is inevitable fact that in the labor market, widespread job displacement is a significant concern, unlike industry 4.0 and industry 5.0, industry 6.0 are increasingly capable of replacing human workers not only in manufacturing but also in skilled professions such as healthcare, justice, and education.[7]This technological transition is expected to

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4 Angel Swastik Duggal and others, 'A Sequential Roadmap to Industry 6.0: Exploring Future Manufacturing Trends' (2022) 16 *IET Communications* 521.

5 Directive - 2018/1972 - EN - Eecc - EUR-Lex' <https://eur-lex.europa.eu/eli/dir/2018/1972/oj/eng> accessed 2 July 2025.

6 Marco Becker and others, 'Toward Antifragile Manufacturing: Concepts from Nature and Complex Human-Made Systems to Gain from Stressors and Volatility' in Peter Letmathe and others (eds), Transformation Towards Sustainability: A Novel Interdisciplinary Framework from RWTH Aachen University (Springer International Publishing 2024) <https://doi.org/10.1007/978-3-031-54700-3_16> accessed 2 July 2025.

7 Carolina Machado and J. Paulo Davim (eds), *From Industry 4.0 to Industry 6.0* (ISTE 2025) 65–66 <https://www.iste.co.uk/book.php?id=2246>.

exacerbate the skills gap, potentially marginalizing employees who do not possessadvanced digital skills.[8]

From an ecological standpoint, the technologies associated with Industry 6.0 are highly energy demanding, and use rare earth elements particularly for quantum computing, data storage, and to run sophisticated robotics.[9] This devices leads to an increase in electronic waste, and the potential for greenwashingdetracts from authentic sustainability globalfarmwork.[10]The advent of Industry 6.0 technologies is poised to fundamentally reshape conventional global supply chains by reducing reliance on cross-border trade, particularly among developed economies that have traditionally dominate international trade. This affectstheir absolute advantage in import and exports. Simultaneously, Industry 6.0 will give a strategic opportunity for LDCs to bypass earlier stages of industrialisation and integrate directly into the advanced technological landscape. This dynamic is likely to intensify global trade competition, challenging existing market system and fostering a more competitive and technologically driven trade environment.In response, developed nations hopefully reconsider the SDT provisions for LDCs and other practical flexibilities under WTO agreements to maintain their trade dominance. This poses a risk of shifting towards bilateral or regional agreements that serve their strategic goals, potentially undermining the WTO's structure and fragmenting global trade governance. In this regard, while Industry 6.0 offers technological advancements, the weakening of SDT principles could marginalize LDCs unless proactive measures are taken to ensure equitable participation.

The rise of Industry 6.0 will also introduce new sources of conflict, particularly concerning intellectual property rights, data sovereignty, and AI standards, all of which could fuel trade disputes.[11]Current WTO-IP frameworks face significant challenges in addressing intricate ownership issues over AI-generated products. This ambiguity may lead to disputes that

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8 Amit Kumar Tyagi, Shrikant Tiwari and Sayed Sayeed Ahmad (eds), *Industry 4.0, Smart Manufacturing, and Industrial Engineering: Challenges and Opportunities* (CRC Press 2024) 797.

9 Europäische Kommission / Gemeinsame Forschungsstelle, G Kamiya and Paolo Bertoldi, *Energy Consumption in Data Centres and Broadband Communication Networks in the EU* (Luxembourg/ : Publications Office of the European Union 2024).

10 Iwona Rummel-Bulska, 'Chapter II.2 - The Basel Convention and Its Implementation' in Irena Twardowska (ed), *Waste Management Series*, vol 4 (Elsevier 2004)
<https://www.sciencedirect.com/science/article/pii/S0713274304800096> accessed 2 July 2025.

11 Tina Javidipour, 'Opportunities and Challenges in the Transition to Autonomous and Adaptive Enterprises in the Era of Industry 6.0' (2024) 1 *Journal of Business and Future Economy* 63.

could hinder innovation and disrupt international trade.[12]Data sovereignty is set to become a significant point of contention in the industry 6.0 era. In response to the unpredictable impacts of technological advancements, WTO members are likely to enact domestic laws aimed at safeguarding privacy and security. Such measures will place substantial compliance burdens on multinational corporations, undermining global competitiveness and provoking retaliatory trade actions. Moreover, the absence of harmonised WTO regulations on AI and other emerging technologies will presents further challenges.[13]Divergent national policies, whether focused on strict ethical standards or favouring unregulated innovation, risk escalating into trade disputes.

Industry 6.0's technological paradigm also will create critical vulnerabilities, particularly by endangering national security through AI-driven espionage, cyber sabotage, cognitive warfare, and data exploitation that threaten state sovereignty. Within this context, Article XXI of the GATT offers a national security exception that allows states to take measures they deem necessary for the protection of their national security. However, the current understanding of Article XXI of GATT focus on conventional arms, fissionable materials, and wartime exigencies. Furthermore, it retains a degree of deference to state discretion but not self-judging under WTO farmwork.[14]Therefore, good faith assessment and a demonstrable nexus between the trade measure and a genuine security threatis required in the industry 6.0 era. If so, measures that restrict the export, transit, or sharing of Industry 6.0 military products shall fall within the ambit of Article XXI(b)(ii) and (iii) of GATT.[15] Moreover, the data-centric nature of Industry 6.0 compels reconsideration of Article XXI(a), which allows states to withhold information whose disclosure would compromise essential security interests. Further, Article XXI may serve as a shield against transparency demands that could undermine cybersecurity or expose national vulnerabilities. In general, the "essential security interests" underscores the evolving nature of threats in a digitized geopolitical landscape and may encourage states to adopt expansive interpretations of WTO security exceptions.

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12 Sofia Vescovo, 'Rise of the Machines: The Future of Intellectual Property Rights in the Age of Artificial Intelligence' (2023) 89 *Brooklyn Law Review* 221.

13 Bekhzod Ochilov, 'The Role of International Organizations in International-Legal Regulation of e-Commerce' [2020] Science and culture on the vision of young scientists and leaders: International Scientific Online Conference <https://www.academia.edu/43500780/The_role_of_International_organizations_in_International_legal_regulation_of_e_commerce> accessed 1 July 2025.

14 Tania Voon, 'Russia Measures Concerning Traffic in Transit' (2020) 114 *American Journal of International Law* 96.

15 Brandon J Murrill, 'The "National Security Exception" and the World Trade Organization'<https://sgp.fas.org/crs/row/LSB10223.pdf>.

Similar to national security, the WTO recognizes a general exception for measures aimed at safeguarding 'public morals'. This exception permits the Members to impose trade restrictions as per Article XIV(a) of the GATSand Article XX(a) of the GATT. However, still the concept of 'public morals' lacks a clear definition, and vary significantly across different countries and cultures.[16]In addition to this legal gap, industry 6.0 will pose a threat on value of human labor and empathy. Particularly unrestricted use of AI in sensitive areas such as healthcare, justice, and warfare raise ethical dilemmas, prompting critical inquiries into accountability and moral responsibility.[17]Furthermore, cultural homogenization, loss of local identities and paradigm shift on consumption standards also another challenge. Future Industry 6.0sophisticated technologies like human augmentation, bio-engineering, and digital twins introduce complex bioethical concerns, especially regarding identity, consent, and bodily integrity.[18]

GATT INDUSTRY 6.0 REGULATORY READINESS

The GATTserves as a multilateral trade framework designed to facilitate trade liberalization by lowering tariffs and other trade obstacles, as well as eradicating discriminatory practices.[19]To fulfill this aim and foster equitable international trade, it operates under two fundamental principles of non-discrimination, namely MFN and NT, along with principles of reciprocity and transparency.[20]However, GATT has faced criticism for its inadequate response to address emerging challenges posed by technological advancements.[21] Presently, digital trade is a significant concern, and in the

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16 Ravindran Rajesh Babu, 'WTO Law and the Protection of Public Morals' 355 <https://ir.iimcal.ac.in:8443/jspui/handle/123456789/1432> accessed 1 July 2025.

17 Trishan Panch and others, 'Artificial Intelligence: Opportunities and Risks for Public Health' (2019) 1 *The Lancet. Digital Health* e13.

18 Koen Bruynseels, Filippo Santoni de Sio and Jeroen van den Hoven, 'Digital Twins in Health Care: Ethical Implications of an Emerging Engineering Paradigm' (2018) 9 Frontiers in Genetics
<https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2018.00031/full> accessed 1 July 2025.

19 Roshani Gunewardene, 'GATT and the Developing World: Is a New Principle of Trade Liberalization Needed?' (1991) 15 *Maryland Journal of International Law* 45.

20 Peter Van den Bossche (ed), 'Principles of Non-Discrimination', *The Law and Policy of the World Trade Organization: Text, Cases and Materials* (2nd edn, Cambridge University Press 2008) <https://www.cambridge.org/core/books/law-and-policy-of-the-world-trade-organization/principles-of-nondiscrimination/2D5B5EC0DF14BD9BE4C20F5BDD820F95> accessed 1 July 2025.

21 Ikenga KE Oraegbunam and Chiugo Onwuatuegwu, 'Addressing the Challenges in The Contemporary International Trading System: The Limitations of General Agreements on Tariffs Trade (GATT) And General Agreements on Trade in Services (GATS)' (2023) 5 *International Journal of Comparative Law and Legal Philosophy* (IJOCLLEP)<https://www.nigerianjournalsonline.com/index.php/IJOCLLEP/article/view/4069> accessed 1 July 2025.

forthcoming era of Industry 6.0, issues such as employee rights and job security, environmental challenges, national security threats, public morality, and health governance will emerge as critical management challenges that will directly or indirectly affect international trade.It is necessary to determine whether GATT is adequately prepared or inadequately prepared to tackle the trade implications of Industry 6.0.

GATT does not contain explicit provisions addressing crucial matters such as environmental n sustainability and ethical labor standards in relation to trade. While GATT does address environmental issues to some extent, its scope is restricted and it does not actively encourage sustainability or establish environmental standards; it merely permits exceptions.[22] This omission reduces its significance in the context of Industry 6.0. Furthermore, GATT's stringent adherence to the MFN and NT principles may hinder the objectives of Industry 6.0, which prioritize technological sovereignty and green innovation.[23]In this regard, states will implement subsidies for clean energy or domestic artificial intelligence development out of necessity, potentially contravening GATT's non-discrimination rules. Again, the geopolitical and technological environment of the industry 6.0 era will promote the establishment of robust regional integration legal frameworks that challenge GATT's uniform liberalization approach. Given GATT's limitations, it is essential to evaluate whether certain provisions of it can be interpreted in alignment with Industry 6.0 goals or amendment are necessary.

A prime provision for such interpretive scrutiny is Article XX, which provides general exceptions to GATT obligations.This exceptional clause allows WTO Members to rationalize trade-restrictive measures aimed at legitimate policy objectives, such as safeguarding the health or life of humans, animals, or plants, as well as conserving finite natural resources.[24] A broader interpretation of this could support initiatives that encourage environmentally sustainable manufacturing or carbon-neutral technologies, which are aligned with both GATT and Industry 6.0.[25] Likewise, a broad interpretation of the public morals exception referenced in Article XX(a) of GATT could be applied to justify regulations concerning ethical artificial

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22 Philippe Sands (ed), *Greening International Law* (Routledge 2014).

23 Uzma Khan, Huili Wang and Ishraq Ali, 'A Sustainable Community of Shared Future for Mankind: Origin, Evolution and Philosophical Foundation' (2021) 13 *Sustainability* 9352.

24 Sarah Ahmad, 'Examining the Inadequacy of the GATT's Rules-Exceptions Paradigm in the Fight Against Climate Change: The Case for a WTO Climate Waiver' (2023) 45 *University of Pennsylvania Journal of International Law* <https://scholarship.law.upenn.edu/jil/vol45/iss1/6>.

25 Timo Gerres and others, 'To Ban or Not to Ban Carbon intensive Materials: A Legal and Administrative Assessment of Product Carbon Requirements' (2021) 30 EconStor Open Access Articles and Book Chapters 249.

intelligence, labor standards, or data protection, all of which are vital components of human-centered Industry 6.0 frameworks.

The MFN principle indicated in GATT is mandated that any trade benefit provided by a member to one nation must also be granted to all other nations, "immediately and unconditionally".[26]This essential rule, which is pivotal to ensuring non-discrimination in international trade, may limit preferential treatment for key sectors that are crucial to Industry 6.0. For example, regional innovation zones or bilateral technology partnerships aimed at promoting localized technological leadership could potentially clash with this principle when specific commitments designed to tailored to specific groups to promote industry 6.0.In a similar vein, the NT obligation forbids WTO members from levying internal taxes or regulations that favor domestic products over imported goods.[27]While this principleaims to curb hidden protectionism, they may restrict the capacity of states to introduce incentives for local development in sectors such as AI-driven production systems, robotics, or sustainable industrial processes, which are fundamental components of Industry 6.0. Consequently, any tax relief or preferential regulatory treatment granted to these domestically developed smart technologies could be contested under industry 6.0 era.

GATT mandates the overall removal of quantitative restrictions and prohibits both import and export bans or quotas.[28]In the context of Industry 6.0, this could present a point of contention and has the potential to obstruct contemporary industrial policies that include data localization requirements, digital export controls, or limitations on essential technology transfers.Furthermore, provisions concerning the conditions for implementing countervailing duties are outlined in Article XVI of GATT and the Agreement on Subsidies and Countervailing Measures impose restriction on subsidies that distort trade.[29]Although these regulations are designed to

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26 Frans Lavdari, 'Principle of Most Favoured Nation: Description, Modern Evolution, and Analysis of the Exceptionality of the Principle in A Contemporary World' (2021) 1 Extensive Reviews 16, 26.

27 Jennifer Hillman and others, 'International Forced Labor Import Bans: A Case for WTO Compatibility' (2024) 55 Georgetown journal of international law 619.

28 Damian Raess, Henry Gao and Ka Zeng (eds), 'Political and Economic Implications of China's WTO Membership', *China and the WTO: A Twenty-Year Assessment: Volume undefined: World Trade Forum* (Cambridge University Press 2023) <https://www.cambridge.org/core/books/china-and-the-wto/political-and-economic-implications-of-chinas-wto-membership/31F2A836E89228D1CCCCF48D0E65CE75> accessed 1 July 2025.

29 Nu Ri Jung, 'Article: Are There "Exceptions" to the SCM Agreement? Applicability of the GATT Exceptions Vis-à-Vis the International Rules on Subsidies' (2023) 57 Journal of World Trade 456 <https://kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals\TRAD\TRAD2023019.pdf> accessed 1 July 2025.

maintain fair competition, they may hinder state-driven innovation policies that are crucial for Industry 6.0. Consequently, subsidies in this domain may violate WTO regulations unless they can be defended under specific exceptions or categorized as non-actionable. Similarly, GATT governs the establishment of customs unions and free trade areas, allows for regional trade integration.[30] However, it offers a certain level of flexibility for regional innovation frameworks, it simultaneously leads to the fragmentation of global trade governance.In this regard, Policy instruments related to Industry 6.0 will increasingly being crafted and executed through free trade agreements (FTAs)and plurilateral arrangements which will resulting in inconsistencies and legal ambiguities within the multilateral trading system.

GATS AND INDUSTRY 6.0

The GATS is a legal framework that accommodates members' domestic policy objectives while promoting trade liberalization in services.[31] Concurrently,Industry 6.0 is transforming the landscape of global services for the future.Therefore,whether GATS can handle this coming issue or not will be the focus of this section, particularly concerning job security, environmental impact, national securityand accommodating LDCs in the industry 6.0 era.While GATS does not directly govern labor rights, it permits member countries to implement domestic regulations concerning the qualifications, standards, and licensing of service providers as long as these measures are objective, transparent, and non-discriminatory.[32] This provision allows members to sustain labor standards without violating WTO commitments. As Industry 6.0 transforms global services, the capacity of WTO members to preserve national labor standards within the GATS framework is essential for protecting job security and ensuring that technological progress does not undermine basic worker protections, particularly in at-risk LDC economies.

On environmental protection, GATS is allowing members to adopt or enforce measures necessary to protect human, animal, or plant life or health

30 Willie Shumba, 'How Relevant Is Customs in the Operation of Free Trade Areas?' (2023) 17 World Customs Journal 43.

31 Sebastian Benz, Janos Ferencz and Hildegunn K Nordås, 'Regulatory Barriers to Trade in Services: A New Database and Composite Indices' (2020) 43 The World Economy 2860.

32 Susy Frankel (ed), 'Trading in Intellectual Property: The TRIPS Agreement and Free Trade Agreements', *Test Tubes for Global Intellectual Property Issues: Small Market Economies* (Cambridge University Press 2015) <https://www.cambridge.org/core/books/test-tubes-for-global-intellectual-property-issues/trading-in-intellectual-property/62366BAB0D1C22E409BB590FFA509640> accessed 1 July 2025.

and to conserve exhaustible natural resources.[33] It is designed to ensure environmental priorities can take precedence over trade commitments when justified.In this context, Articles XIVhold particular importance within the framework of Industry 6.0. These exceptions under GATS afford WTO members essential leeway to emphasize environmental safeguarding over trade commitments, when necessary, thus allowing them to tackle emerging sustainability issues brought about by innovations in Industry 6.0. However, Industry 6.0 may make it harder to control environmental practices of service providers, especially when services are delivered across borders and under varied regulatory environments.

Furthermore, national security and public morality are preserved under GATS. Within the realm of Industry 6.0, these protective measures are vital. In this regard, state parties are free to address new cybersecurity risks and ethical dilemmas associated with sophisticated digital environments in Industry 6.0. In this context, GATS equips members with the essential policy latitude to implement strategies that safeguard national security and maintain public morality, ensuring that swift technological advancements do not compromise sovereignty, social welfare, or ethical principles. Therefore, the provisions of GATS should be interpreted as providing WTO members the adaptability needed to confront the intricate social, ethical, and security challenges that arise in the industry 6.0 environment.

For addressing development disparities, Article IV of GATS obliges developed members to assist developing and LDCsby improving their access to global services markets.As mentioned below, LDCs, GATS offers important flexibilities, such as the LDC Services Waiver, allowing preferential treatment for LDC services. However, with Industry 6.0's disruptive technologies, LDCs may face greater challenges in technological integration and access to advanced services such as big data analytics,AI, and automation technologies. Although GATS' provisions help, the digital divide remains a significant barrier to LDC participation in the global service economy. Enhanced capacity-building under Article IV is critical, but LDCs must find ways to navigate technological dependency in an increasingly connected world while managing socio-economic disparities that new technologies may exacerbate.

LDCs AND INDUSTRY 6.0

LDCs acceding often face WTO-plus obligations but receive WTO-minus rights.[34] Later the Doha Declaration and the 2002 General Council decision

33 Charlotte E Blattner, 'The Unanswered: Indirect Protection through the GATT' in Charlotte E Blattner (ed), *Protecting Animals Within and Across Borders: Extraterritorial Jurisdiction and the Challenges of Globalization* (Oxford University Press 2019) <https://doi.org/10.1093/oso/9780190948313.003.0004> accessed 1 July 2025.

34 Solomon Girma, 'Challenges of on Terms to Be Agreed in WTO: LDC's Experiences for Ethiopian' (2019) 86 *Journal of Law, Policy and Globalization* 6.

introduced special measures LDC's.[35]Although there is no specific WTO definition of LDCs, the UN Economic and Social Council, through its independent Committee for Development Policy identifies and updates the list of LDCs every three years.Marrakesh agreement offers flexible and special procedure for LDCs.[36] Particularly Article XI (2) of this agreementensures that LDCs are not obligated to undertake commitments that exceed their financial, trade, or institutional capacities.In line with its Special and Differential Treatment set up, the WTO grants LDC's strategic policy space and extended transition periodsto support their development priorities.[37]

In principle Industry 6.0 aligns with the WTO's foundational objective of accommodating LDC's which offers policy space to adopt Industry 6.0-compatible strategies while respecting multilateral commitments.As elsewhere mentioned, Article XVIII of GATT is essential recognition to implement import restrictions that protect infant industries pivotal for Industry 6.0 adoption. Again, the Special Safeguard allows LDCs to temporarily increase tariffs in response to sudden import surges or price depressions, particularly in agricultural products.[38] This also works for nascent Industry 6.0 sectors which are notmaturely exposed to global competition. Simultaneously, the Enabling Clause and Duty-Free Quota-Free market access initiatives expand LDCs' export opportunities, granting preferential entry into developed-country markets without requiring reciprocal obligations.[39] This also an opportunity for LDC's in industry 6.0 era.

As elsewhere mentioned, GATS permits WTO members, including LDCs, to impose restrictions on services trade as a safeguard during balance-of-

35 *Ibid.*

36 Rüdiger Wolfrum and Peter-Tobias Stoll, 'Agreement Establishing the Worldtrade Organization' (Brill 2006)<https://brill.com/display/book/edcoll/9789047418184/Bej.9789004145634.1-704_002.xml> accessed 2 July 2025.

37 Valentina Vadi, 'Chapter 5: Human Rights and Investments at the WTO' (2018) <https://www.elgaronline.com/edcollchap/edcoll/9781782549116/9781782549116.00013.xml> accessed 2 July 2025.

38 Qi Sun, 'The Study on Exception Clauses of Cross-Border Data Flows in International Trade Agreements' (2025) 2 *Journal of Theory and Practice in Humanities and Social Sciences* 1.

39 Alan Wm Wolff (ed), 'Development at the WTO', *Revitalizing the World Trading System* (Cambridge University Press 2023)<https://www.cambridge.org/core/books/revitalizing-the-world-trading-system/development-at-the-wto/A14A4FC433C9873799353A6035675BF1> accessed 2 July 2025.

payments difficulties.[40] More importantly, Article IV of GATS goes beyond exceptions by mandating positive efforts to increase developing countries' participation in global services trade, including access to technology, distribution channels, and information networks which includes industry 6.0 of digital services, AI logistics, and others. Similarly, the LDC Services Waiver framework allows WTO members to grant preferential market access to LDC service suppliers without extending the same treatment to other members, enhancing LDC participation in global services trade.[41] This will similarlyallow preferential treatment for LDC service suppliers in sectors central to Industry 6.0.

With regards to TRIPS, it grants LDCs extended transition periods during which they are not required to enforce intellectual property protections, acknowledging their institutional and economic constraints.[42] These transition periods are critical for allowing LDCs to develop domestic IP regimes without stifling technological adaptation, ensuring that emerging Industry 6.0 technologies, especially in healthcare and pharmaceuticals, can meet urgent public health needs without breaching IP obligations. Furthermore, Article 67 of TRIPS obliges developed countries to provide technical and financial assistance, offering LDCs a structured pathway to build robust IP management systems aligned with the complex demands of Industry 6.0.Complementing these provisions, the Doha Declaration on TRIPS and Public Health affirms that WTO members may prioritize public health over patent rights, further empowering LDCs to lawfully suspend pharmaceutical patents to address critical health concerns, thus reinforcing the role of IP flexibilities as a catalyst for inclusive innovation.[43]

Finally, in terms of industrial policy, Agreement on Subsidies and Countervailing Measures(expired)legitimized certain subsidies, including those aimed at regional development and environmental upgrades, which gives an appropriate lessonin advancing the goals of Industry 6.0. These flexibilities enable LDCs to invest in digital infrastructure, automation, and sustainable production systems, helping their industries transition toward

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40 Johanna Jacobsson (ed), 'The GATS Rules on Economic Integration Agreements (EIAs)', *Preferential Services Liberalization: The Case of the European Union and Federal States* (Cambridge University Press 2019) <https://www.cambridge.org/core/books/preferential-services-liberalization/gats-rules-on-economic-integration-agreements-eias/238E4550F5A0A9CC515 C02D725E00F55> accessed 2 July 2025.

41 'Doha Dead and Buried in Nairobi: Lessons for the WTO' (2017) 16 *Journal of International Trade Law and Policy* 49.

42 Carlos M Correa, 'Interpreting the Flexibilities Under the TRIPS Agreement' in Carlos M Correa and Reto M Hilty (eds), *Access to Medicines and Vaccines* (Springer International Publishing 2022).

43 Hans Löfgren, 'The Trans-Pacific Partnership Agreement: A Threat to Affordable Medicines and Public Health' (2011) 4 *Southern Med Review* 49.

antifragility and global competitiveness. Complementing this, the WTO's Aid for Trade initiative, particularly through the Enhanced Integrated Framework, offers LDCs technical and financial assistance to overcome structural barriers to Industry 6.0 adoption.Again, by supporting value chain development, private sector engagement, and regional integration, Aid for Trade strengthens the digital and industrial transformation necessary for LDCs to fully harness the opportunities of Industry 6.0.

LEGAL CHALLENGES FACING THE WTO IN THE AGE OF INDUSTRY 6.0

The technological and regulatory paradigm developments of Industry 6.0 have left the WTO's legal framework ever moreoutdated. The GATS's unclear regulations on cross-border data governance and digital services, ongoing ambiguities in the classification of goods and services, especially with regard to digital transmissions, the opaqueness of AI-driven regulatory decision-making that contradicts the TBT and SPS Agreements' WTO transparency and justification requirements, the antiquated TRIPS framework that ignores AI-generated or decentralised intellectual property rights, and the paralysis of the WTO dispute settlement mechanism that is currently unable to resolve extremely complex and technical digital trade disputes are some of the major legal obstacles. The WTO has to swiftly implement structural and substantive changes if it is to remain effective and relevant in the digital age. These include reorganising the Appellate Body with adjudicators who are familiar with digital technologies and data law; creating a Digital Trade Agreement to clarify the legal status of data, algorithms, and electronically transmitted goods; integrating WTO disciplines with plurilateral digital trade frameworks to ensure multilateral coherence and regulatory convergence; and updating TRIPS to accommodate AI inventorship and open-source innovation systems.

Industry 6.0, marked by decentralized manufacturing, AI-human integration, quantum technologies, and data-sovereign industrial networks, has highlighted profound institutional and legal deficiencies within the WTO framework.[44]A global economic order based on tangible commodities and analogue services was intended to be facilitated by the WTO's fundamental accords, the GATT, GATS, and TRIPS, which were established on the tenets of multilateralism and trade liberalisation. The current legal framework of the WTO is incompatible with Industry 6.0, which is characterised by decentralised algorithmic production systems, AI-generated content, cross-border data flows, and intangible digital assets. The current WTO framework is becoming less and less capable of regulating, deciding, and addressing the ever-changing demands of the global digital economy as a result of this gap.

44 Andrew Keane Woods, 'Digital Sovereignty + Artificial Intelligence' in Anupam Chander and Haochen Sun (eds), *Data Sovereignty: From the Digital Silk Road to the Return of the State* (Oxford University Press 2023) <https://doi.org/10.1093/oso/9780197582794.003.0006> accessed 2 July 2025.

CROSS-BORDER DATA FLOWS AND THE GATS LIMITATION

The WTO is confronted with intricate legal issues in the Industry 6.0 age as a result of antiquated trade regulations. Despite being crucial to AI and cloud-based services, cross-border data transfers and data localisation are not specifically regulated by the GATS.[45] Although Article XIV allows for exceptions for public morality and privacy, instances like US Gambling (DS285) demonstrate the difficulty of defending such limitations, particularly in AI circumstances where algorithmic opacity obstructs transparency.[46] In a similar vein, technologies such as 3D printing are making it harder to distinguish between the products and services that form the basis of GATT 1994 and GATS. The WTO's e-commerce moratorium, which forbids customs taxes on electronic communications and is fiercely opposed by developing nations looking to collect digital tariffs, further exacerbates this issue. Additionally, the increasing use of AI in regulatory decision-making for safety, health, and customs raises concerns about compliance with the TBT (Article 2.2) and SPS (Article 5.1) Agreements, which require clear, scientific explanations for trade restrictions. Failure to offer such rationale violates WTO commitments, as was shown in EC Hormones (DS26). WTO members run the danger of breaking due process and being sued when AI systems are inexplicable. The WTO's analog-era, human-centric regulations are becoming more and more out of step with the needs of data-driven, algorithmic trade if doctrinal change is not implemented.

The current legal boundary between commodities and services that supports the WTO's dual regime of the GATT and GATS is essentially blurred by Industry 6.0 technologies like 3D printing, AI-generated outputs, and cloud-based manufacturing. For instance, a digital 3D printing file sent across international borders may be considered a service under GATS, while the physical product that is created domestically is a good subject to GATT. Particularly in cases where value is found more in the ethereal input (the file or algorithm) than the tangible product, this hybrid character calls into question the logical coherence of WTO rules.The obligations pertaining to national treatment of commodities and tariff bindings are outlined in Articles II and III of the GATT 1994. [47] In contrast, the GATS regulates trade in

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45 Prashant Reddy, 'Cross-Border Data Flows in WTO Law: Moving Towards an Open, Secure and Privacy-Compliant Data Governance Framework' (*SpicyIP*, 27 April 2020) <https://spicyip.com/2020/04/cross-border-data-flows-in-wto-law-moving-towards-an-open-secure-and-privacy-compliant-data-governance-framework.html> accessed 2 July 2025.

46 Neha Mishra, 'Privacy, Cybersecurity, and GATS Article XIV: A New Frontier for Trade and Internet Regulation?' (2020) 19 *World Trade Review* 341.

47 'The Role of Digital Products Under the WTO: A New Framework for GATT and GATS Classification | *Chicago Journal of International Law*' <https://cjil.uchicago.edu/print-archive/role-digital-products-under-wto-new-framework-gatt-and-gats-classification> accessed 2 July 2025.

services but does not specifically address how digital files, software, and mathematical models that support contemporary industrial processes should be classified.

Due to its draughting for an analogue economy, the GATS Schedules of Commitments issued by Members are frequently vague or silent on digital trade.This legal issue is made much more difficult by the WTO's moratorium on customs charges for electronic transmissions, which has been in effect since 1998 and is frequently extended. Even though it is in favour of liberalising digital trade, developing nations like South Africa, Indonesia, and India have expressed concern that it will prevent them from earning money from high-value digital imports, like software, designs, or AI tools, which are now essential components of many Industry 6.0 products. Due to the absence of legal clarity on whether these transmissions should be regarded as goods or services, enforcement and classification issues arise as the value of products moves from their physical form to their digital design.Without reform, the continuous use of antiquated legal differences puts emerging nations at risk for regulatory fragmentation, trade conflicts, and a reduction in their policy space. The WTO could have to reevaluate the goods-services divide in order to adjust, perhaps by developing a new digital trade protocol or adopting interpretive standards that take into consideration the hybrid goods and intangible industrial assets that are essential to Industry 6.0.

ALGORITHMIC REGULATION AND TRANSPARENCY OBLIGATIONS

Under WTO law, governments' growing dependence on artificial intelligence (AI) systems to perform regulatory tasks including customs control, health inspections, and product safety evaluations creates serious problems in the context of Industry 6.0. These AI-driven procedures may be in disagreement with WTO commitments that demand clear, evidence-based, and appropriate trade-related laws, especially when they include intricate or opaque "black-box" models.[48] In specifically, two WTO accords are in issue:

> ***Article 5.1*** *of the SPS Agreement stipulates that sanitary and phytosanitary measures must be based on scientific risk assessments, with measures tailored to the risks involved, based on internationally accepted scientific standards;* ***Article 2.2*** *of the TBT Agreement requires that technical regulations must be based on available scientific and technical information and not*

48 Marc Rotenberg, 'Artificial Intelligence and the Right to Algorithmic Transparency' in Elisa Stefanini and others (eds), *The Cambridge Handbook of Information Technology, Life Sciences and Human Rights* (Cambridge University Press 2022) <https://www.cambridge.org/core/books/cambridge-handbook-of-information-technology-life-sciences-and-human-rights/artificial-intelligence-and-the-right-to-algorithmictransparency/A92EE127AF24D868066EC0AEAE3A370C> accessed 2 July 2025.

be more trade-restrictive than necessary to fulfil legitimate objectives, such as health and safety.

With the advent of Industry 6.0, this precedent has important ramifications.AI-powered regulatory judgements, particularly those driven by deep learning or quantum models, might not be transparently reasoned or auditable. A nation may be found to be in violation of its WTO commitments under the TBT and SPS Agreements if it implements trade restrictions based on AI results without offering a transparent justification or a verified, scientific foundation.

AI models that are used to make regulatory decisions pertaining to trade must be comprehensible and able to generate arguments that can be supported by the law.[49] If not, WTO members run the possibility of being contested for non-compliance, particularly in cases where algorithmic results are based on probabilistic reasoning rather than accepted scientific principles or cannot be meaningfully examined. Members should think about implementing "human-in-the-loop" processes, technical documentation specifications, or third-party audits to verify AI decisions that impact trade in order to future-proof their trade regimes. Without these safeguards, the use of AI in regulation may violate WTO rules on transparency and necessity, weaken legal certainty, and erode due process protections especially in cases involving food safety, product conformance, or digital customs controls in an Industry 6.0 ecosystem.

TRIPS AND THE CRISIS OF AI-GENERATED INTELLECTUAL PROPERTY

Industry 6.0 reveals structural flaws in the TRIPS Agreement of the WTO, which assumes territorial intellectual property rights and human inventorship. Innovations that do not match this model include open-source ecosystems, blockchain-authenticated intellectual property, and AI-generated inventions.[50] Article 9 of TRIPS (via the Berne Convention) links copyright to natural persons, while Article 27(1) mandates patentability for all inventions but implicitly presumes a human inventor. [51] This gap is

49 AK Zharova, 'Achieving Algorithmic Transparency and Managing Risks of Data Security when Making Decisions without Human Interference: Legal Approaches' (2023) 1 *Journal of Digital Technologies and Law* 973.

50 Adil S Al-Busaidi and others, 'Redefining Boundaries in Innovation and Knowledge Domains: Investigating the Impact of Generative Artificial Intelligence on Copyright and Intellectual Property Rights' (2024) 9 *Journal of Innovation & Knowledge* 100630.

51 Wei Zhuang (ed), 'Interpreting the TRIPS Agreement for Facilitating Innovation and Transfer of ESTs', *Intellectual Property Rights and Climate Change: Interpreting the TRIPS Agreement for Environmentally Sound Technologies* (Cambridge University Press 2017) <https://www.cambridge.org/core/books/intellectual-property-rights-and-climate-change/interpreting-the-trips-agreement-for-facilitating-innovation-and-transfer-of-ests/6EC30A5A970433FAEF831ADC44B434CB> accessed 2 July 2025.

demonstrated in the DABUS dispute (UK, US, EU), wherein AI-generated patents were denied since no human inventor was present.[52] Divergent national procedures may result in IP fragmentation and investor-state disputes in the absence of WTO guidance. Maintaining legal coherence requires reforming TRIPS to acknowledge open-source licensing, blockchain proof systems, and AI inventorship.[53]

The WTO Appellate Body's paralysis since 2019 has also made binding dispute settlement under DSU Article 17 impossible. In issues involving data limitations, algorithmic prejudice, and cybersecurity measuresall of which call for adjudicators with both legal and technical expertise this is especially detrimental. Lack of specialised panels and a non-operational appeals process make it difficult to enforce WTO regulations on digital trade. These institutional differences prevent regulatory conflicts like those between the EU's GDPR and US surveillance lawsfrom being settled multilaterally. Because of this, members are resorting to plurilateral agreements like the U.S.-Japan Digital Trade Agreement and DEPA, which provide more flexible governance but run the risk of dismantling the multilateral trade system and undervaluing the participation of the WTO.

THE PROSPECTS OF THE WTO IN THE AGE OF INDUSTRY 6.0

The WTO could develop into a global trade authority with digital competence by rethinking its DSU procedure, encouraging digital inclusivity, and reforming the WTO agreement, particularly IPR standards. The WTO will be able to maintain its relevance and lead the process of creating the legal framework that regulates the global digital economy as a result. However, in an era where global trade is governed by algorithmic intelligence, data, and code, there is a risk of strategic marginalisation.

Normative Expansion

The WTO is in a great position to establish a multilateral framework for digital trade that would regulate electronic transmissions, digital goods, AI-enabled services, and cross-border data flows.[54] There is currently no clear

52 'High Court Powers down DABUS Patent Prospects in Australia' (*Davies Collison Cave*, 15 November 2022) <https://dcc.com/news-and-insights/high-court-powers-down-dabus-patent-prospects-in-australia/> accessed 2 July 2025.

53 Ching-Fu Lin, Shin-yi Peng and Thomas Streinz (eds), 'Reconceptualizing World Trade Organization Law for the Artificial Intelligence Economy', *Artificial Intelligence and International Economic Law: Disruption, Regulation, and Reconfiguration* (Cambridge University Press 2021) <https://www. cambridge. org/core/books/artificial-intelligence-and-international-economic-law/reconceptualizing-world-trade-organization-law-for-the-artificial-intelligence-economy/2AF4DBE5234DC729A0A7621F7326C19D> accessed 2 July 2025.

54 Anupam Chander, 'Artificial Intelligence and Trade' in Mira Burri (ed), *Big Data and Global Trade Law* (Cambridge University Press 2021)<https://www. cambridge.org/core/books/big-data-and-global-trade-law/ artificial-intelligence-and-trade/4A03E8C7FA10640DB3791FB1503EA7C9> accessed 2 July 2025.

legal guidance on how digital transmissions, algorithms, and AI-generated information should be classified or handled under existing agreements like the GATT 1994 and GATS. The Joint Statement Initiative (JSI) on E-Commerce offers WTO members a promising forum for negotiating legally binding regulations on important topics, such as cross-border data flows, source code protection (as modelled by TRIPS and the TBT Agreement), prohibitions on unwarranted data localisation, and non-discrimination in digital services (under GATS Articles II and XVII). The World Trade Organisation might regain its position as the primary regulator of international digital trade in the age of Industry 6.0 and lessen the legal fragmentation brought about by regional agreements such as the USMCA, CPTPP, or DEPA by implementing such a system.

Legal Modernization

In order to handle the changing reality of AI-generated ideas, blockchain-authenticated intellectual property, and open-source industrial ecosystems, the WTO has a crucial chance to start doctrinal reform of the TRIPS Agreement. Non-human or algorithmic works are not protected by current TRIPS rules since they imply human inventorship and authorship, especially Article 27(1) on patentability and Article 9, which integrates the Berne Convention for copyright protection. Patent office's routinely denied applications naming an AI system as the inventor, claiming a lack of legal personality.[55] The legal void within the TRIPS Agreement has been prominently illustrated by the DABUS litigation in the United States, United Kingdom, and European Union, where patent applications for AI-generated inventions were rejected due to the absence of a human inventor.If TRIPS remains silent on such developments, the risk of incoherence in international IP law will only intensify.

To address the above challenges, the WTO is uniquely positioned to spearhead reform by:

(i) legally recognizing algorithmic or non-human inventorship under TRIPS Article 27(1);

(ii) validating blockchain-based IP registries and distributed ledger technologies (DLTs) as legitimate forms of administrative procedures consistent with TRIPS Article 62; and

(iii) extending the flexibilities under TRIPS Article 31 to permit algorithmically determined compulsory licensing for public interest purposes, particularly in the fields of AI-generated pharmaceuticals and climate technologies.

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55 Mackenzie Caldwell, 'What Is an "Author"?-Copyright Authorship of AI Art Through a Philosophical Lens' (2023) 61 Houston Law Review 411.

Such reforms are essential to ensure the continued relevance of TRIPS in the context of Industry 6.0 and to future-proof the global intellectual property regime against the disruptive effects of autonomous innovation and decentralized technological ecosystems.

Reinvigorating WTO Dispute Settlement

In order to address the issues of Industry 6.0, the WTO has a significant chance to reform its dispute resolution process by creating expert rosters and specialised panels in fields like artificial intelligence, data privacy, and cybersecurity. Since the Appellate Body has not been in operation since 2019 (DSU Article 17), it takes both legal and technical know-how to resolve complicated digital trade disputes, including algorithmic bias or GDPR–GATS contradictions. As demonstrated in EC Hormones (DS26), procedural reforms might include establishing standing panels on digital commerce, permitting technical amici curiae, and bolstering science-based decisions under the TBT and SPS Agreements.[56] In order to meet its development mandate, the WTO can concurrently promote open-source platforms, digital infrastructure, and technology transfer to developing countries through tools such as the Trade Facilitation Agreement and TRIPS Article 66.2 (Marrakesh Agreement, Article IV). Thanks to these advancements, the WTO would continue to play a significant role in the flexible, inclusive, and legally sound regulation of the digital economy.

Economic Inclusivity

The WTO is in a privileged spot to further its development mandate under Article IV of the Marrakesh Agreement by actively assisting LDCs and developing nations in integrating into the new Industry 6.0 environment. As digital technologies like decentralised manufacturing, artificial intelligence, and quantum computing transform industrial value chains, there is a growing risk of a growing global digital divide. Without focused assistance, a large number of LDCs might not be able to take advantage of this change.[57] The WTO can use its current legal framework specifically, Article 66.2 of the TRIPS Agreement and the Trade Facilitation Agreement to address issue and encourage more broad industrial participation. As part of Industry 6.0, developed members are required by Article 66.2 to promote technology transfer to LDCs, which may involve providing access to digital infrastructure, AI research, and training in developing technologies. LDCs

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56 Mohammad Abualethem Nsour, 'The WTO and Using Digital Economy Technologies: Surviving the Race With Preferential Trade Agreements' (2023) 57 Journal of World Trade<https://kluwerlawonline.com/api/Product/ CitationPDFURL ? file=Journals\TRAD\TRAD2023031.pdf> accessed 2 July 2025.

57 Thomais Gkrimpizi, Vassilios Peristeras and Ioannis Magnisalis, 'Classification of Barriers to Digital Transformation in Higher Education Institutions: Systematic Literature Review' (2023) 13 *Education Sciences* 746.

can more easily engage in global innovation ecosystems by facilitating the cross-border movement of digital tools, expertise, and data through trade facilitation measures.

For development-oriented digital trade policy, the WTO can serve as a coordinating forum by supporting regional AI innovation hubs, promoting open-source industrial platforms, and investing in digital capacity-building. Such actions would guarantee that WTO trade regulations continue to be fair and applicable in a digitalised global economy, in addition to reducing technical asymmetries.

CONCLUSION

Industry 6.0 presents both an unprecedented opportunity and a profound challenge for the World Trade Organization. As global trade becomes increasingly driven by algorithmic intelligence, digital assets, decentralized manufacturing, and data-sovereign systems, the WTO's foundational legal instruments like GATT, GATS, and TRIPS, are showing signs of structural obsolescence. This research has demonstrated that the existing WTO framework lacks the doctrinal coherence and normative adaptability necessary to regulate digital trade, classify hybrid goods and services, accommodate AI-generated intellectual property, or address cross-border data governance. Yet, the WTO is not without hope. Through doctrinal reinterpretation, legal modernization, and institutional innovation, it can reclaim its central role in shaping global trade law. A Digital Trade Protocol, reformed TRIPS provisions for non-human innovation, specialized adjudicatory bodies for technologically complex disputes, and enhanced development mechanisms for LDCs represent key pillars for WTO reform in the Industry 6.0 era. To remain relevant and effective, the WTO must act with urgency and foresight. If it fails to adapt, it risks being supplanted by fragmented plurilateral regimes and losing its normative authority over the global trading system. If it embraces reform, however, the WTO can lead the transformation of international trade governance into a digitally competent, inclusive, and forward-looking multilateral order fit for the 21st century.