Brief: Harnessing Standards and Regulation to Drive Innovation for Grand Societal Challenges

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Addressing complex grand societal challenges such as climate change, technological transformation, and ethical AI deployment requires a strategic blend of **regulatory frameworks** and **industry standards**. These instruments can guide innovation by providing parameters of information and knowledge, thereby reducing uncertainty and aligning market behaviour with public interest goals. In this brief, we look at empirical academic evidence, blended with policy developments to understand how standards and regulations are used to drive innovation for 3 grand societal challenges: 1) Net zero and environmental sustainability, 2) Advance manufacturing, and 3) AI governance and responsible innovation.

1. Net Zero and Environmental Sustainability

Environmental regulation and standards have proven to be powerful tools in stimulating green innovation. For example, **performance-based emissions regulations** in the automotive and energy sectors have led to increased green patenting and the development of low-carbon technologies (Deng et al., 2024; Rozendaal & Vollebergh, 2021, 2024). In the Netherlands, changes to housing energy performance standards catalysed innovation in sustainable construction (de Vries & Verhagen, 2016).

ISO 14001, an environmental management standard, has been widely adopted across Europe and Asia, promoting eco-innovation and market access (Testa et al., 2014; McGuire, 2014). However, its rigid structure may dampen the positive effects of innovation in some contexts (Valero-Gil et al., 2023).

In parallel, the **International Organisation for Standardisation (ISO)** is launching its first **Net Zero Standard** at COP30 in November 2025. Building on the ISO Net Zero Guidelines (IWA 42:2022), the new standard will provide sector-specific pathways and clearer requirements for interim and long-term targets. It is being developed collaboratively by over 170 national standards bodies, including the British Standards Institution (BSI) and ICONTEC (Net Zero Now, 2025). These standards are expected to accelerate global uptake of credible Net Zero strategies, especially when independently verified, and will support businesses in aligning with regulatory frameworks and ESG expectations.

In **China**, environmental regulation has stimulated green technology innovation, particularly in manufacturing (Wang et al., 2022; Liu & Xie, 2020). Meanwhile, **Germany** has leveraged its strong participation in ISO committees to align industrial competitiveness with sustainability goals (Blind, 2019).

2. Advanced Manufacturing

Process and technological standards such as **ISO 9001** (quality management) and **ISO 14001** (environmental management) have long supported incremental innovation, quality assurance, and environmental performance. These standards enable firms to adopt digital technologies like **Industry 4.0**, **Industrial Internet of Things (IIoT)**, and **digital twins**, fostering modularity and supply chain coordination (Manders et al., 2016; Giménez Espín et al., 2023).

Countries like **South Korea** have shown that safety regulations can positively influence innovation, particularly in construction and manufacturing sectors, with firms perceiving regulatory compliance as a driver of technological advancement (Shin et al., 2021). In the **UK**, technology standards have supported incremental innovation in manufacturing but may reduce incentives for radical breakthroughs (Foucart & Li, 2021).

China's approach to environmental regulation in manufacturing has been dualistic—while it has stimulated green patenting, it has also constrained export competitiveness due to regulatory rigidity (Kesidou & Wu, 2020; Liu & Xie, 2020).

Studies have shown that standards and regulation can act as strategic levers for enabling innovation in advanced manufacturing by accelerating technology adoption (for e.g., Faraday Battery Challenge in the UK), ensure interoperability and cybersecurity, and supporting workforce transformation.

3. AI Governance and Responsible Innovation

AI governance presents unique challenges due to its rapid evolution and cross-sectoral impact. **Singapore** has emerged as a global leader in responsible AI governance through its **Model AI Governance Framework**, which promotes transparency, explainability, and human-centric design. This framework relies on **soft law mechanisms**; voluntary standards and co-regulation which allow flexibility while maintaining ethical safeguards (Blind & Münch, 2024).

Singapore has taken a **multi-layered and agile approach** to AI governance. In 2024, it launched the **Model AI Governance Framework for Generative AI (MGF-Gen AI)**, which consists of nine dimensions that address ethical risks while promoting innovation. The framework was developed by the **AI Verify Foundation** and the **Infocomm Media Development Authority (IMDA)**, with input from global stakeholders including Microsoft, OpenAI, and the US Department of Commerce (IMDA, 2024)

In the **European Union**, the proposed **AI Act** introduces a risk-based regulatory framework that classifies AI systems and imposes obligations based on their potential impact. This

approach aims to balance innovation with fundamental rights and safety, also found in deep decarbonisation efforts in Europe (Geels et al., 2019).

Canada and **Japan** have adopted national standardisation strategies to strengthen innovation ecosystems, focusing on interoperability and ethical AI deployment (Blind & Mangelsdorf, 2016). For example, Japan's AI governance is rooted in a **soft-law approach**, promoting voluntary compliance through nonbinding guidelines. The country's cultural optimism about AI and its emphasis on "Society 5.0" underpin its preference for agile governance over precautionary regulation. Japan's approach aligns with the OECD AI Principles and supports global cooperation, particularly with the United States (CSIS, 2025). In contrast, **China** has developed indigenous telecom standards to enhance its strategic autonomy, despite limited intellectual property ownership (Yan, 2007).

4. Strategic Integration and Policy Implications

International standards are positively associated with R&D investment and patenting, enhancing global competitiveness and facilitating cross-border collaboration (Blind & Jungmittag, 2008; Blind & Münch, 2024). Conversely, national standards may hinder innovation by creating localised lock-ins and reducing scalability (Mangiarotti & Riillo, 2014).

To maximise impact, policymakers should:

- **Align standards and regulation with innovation policy** to guide technological development toward societal goals.
- **Foster public-private partnerships** in standard development to ensure relevance and adaptability.
- **Promote international harmonisation** to reduce trade barriers and support global innovation ecosystems.
- **Leverage informal regulation**—such as norms and codes of conduct—to complement formal mechanisms and encourage responsible innovation

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