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Exploring How Regulatory Sandboxes act as an Institutional Catalyst for AI-driven Business Model Innovation

Duc Nhat Anh Nguyen
National Economics University, Hanoi, Vietnam
Email: nhatanhnd.hn@gmail.com

Abstract

Regulatory sandboxes have emerged as adaptive policy instruments that enable firms to test innovative technologies under controlled conditions while allowing regulators to observe, learn, and refine governance frameworks. This study conceptualizes the regulatory sandbox as an institutional catalyst for AI–driven business model innovation, emphasizing its dual role in promoting experimentation and institutional learning. Drawing on institutional theory and dynamic capabilities theory, the research develops a comparative framework that explains how sandbox design and governance structures shape organizational learning, legitimacy and capability building. Using secondary data from policy reports, institutional documents,and international databases, the study examines three national cases: the UK, Japan, and Kenya, each representing distinct levels of institutional maturity, governance orientation and development priorities. The cross-case analysis shows that while all sandboxes aim to balance innovation and regulation. The UK's collaborative model emphasizes ethical governance, Japan's centralized framework aligns sandboxing with industrial strategy and Kenya's inclusive approach integrates capacity building and digital inclusion. These findings extend theoretical understanding by showing that regulatory sandboxes function not only as legal tools but also as dynamic institutional mechanisms that embed learning, flexibility and legitimacy within governance systems. The study provides practical guidance for policymakers seeking to design sandbox frameworks that promote responsible AI experimentation and support institutional adaptation across diverse economic contexts.

Keywords**:** *Artificial intelligence; Business model innovation; Dynamic capabilities; Institutional theory; Regulatory sandbox.*

1. Introduction

The digital transformation of the global economy has accelerated the emergence of new governance challenges, as rapid advances in artificial intelligence (AI), data analytics and automation outpace existing regulatory systems (OECD, 2023). In this evolving context, innovation increasingly depends on institutional mechanisms that can balance experimentation with accountability (Nguyen et al., 2025). Regulatory sandbox has become a central policy instrument for promoting responsible innovation and adaptive regulation (Ford and Ashkenazy, 2025). A regulatory sandbox is an experimental legal framework that allows firms to test novel technologies, products, or services in real market conditions under temporary regulatory exemptions and close supervision (Chen and Taeihagh, 2025). This arrangement provides a structured environment for experimentation that enables regulators to observe emerging risks, learn from innovation processes and develop evidence-based policies while allowing firms to refine their business models and compliance strategies in a controlled setting. The concept was first introduced by the UK's Financial Conduct Authority in 2016 as a means to stimulate financial technology development through supervised market testing (Cornelli et al., 2024). Following its success, the sandbox model spread rapidly across jurisdictions including Australia, Singapore, Japan and the Netherlands, and expanded beyond the financial sector into areas such as data governance, autonomous mobility, healthcare robotics and sustainable energy (Johnson, 2022). This global diffusion illustrates a growing consensus that regulatory sandboxes represent not merely technical tools but institutional innovations that reconcile flexibility with control. Supporting dynamic learning processes, enable cross-sector collaboration and strengthen public trust in emerging technologies (OECD, 2023).

Despite their widespread adoption, several critical issues remain unresolved. Theoretical and empirical studies reveal that sandbox design and implementation vary significantly across countries, leading to differences in objectives, institutional arrangements, and regulatory engagement (Kálmán, 2025). Some models prioritize regulatory learning and adaptive policy design, while others focus on accelerating business experimentation and market entry (Beckstedde et al., 2023). These inconsistencies raise fundamental questions about how sandbox functionalities such as regulatory flexibility, learning capability and legitimacy building operate as mechanisms

of institutional change. Moreover, most existing research has concentrated on the financial sector, offering limited understanding of how sandboxes function in other high-risk, data-intensive domains such as AI (Chen and Taeihagh, 2025).

AI presents unique challenges to governance due to its dependence on vast data ecosystems, algorithmic opacity, and societal implications that extend beyond conventional risk management frameworks (Mariani et al., 2023). In this context, regulatory sandboxes serve as adaptive policy laboratories where AI technologies can be tested safely, enabling regulators and innovators to co-develop ethical and technically robust solutions before market deployment (Ford and Ashkenazy, 2025). They facilitate institutional learning through iterative experimentation and provide the infrastructure for developing AI-driven business model innovation (BMI), where firms restructure value creation and capture processes to align with emerging regulations, social expectations and technological capabilities (Foss and Saebi, 2017; Teece, 2018).

However, the relationship between regulatory sandbox design, institutional learning and AI-driven BMI remains underexplored, particularly across countries with differing institutional maturity and regulatory capacity. This study addresses this gap by conceptualizing regulatory sandboxes as institutional catalysts that foster AI-based innovation through flexibility, collaboration, and adaptive governance. Drawing on institutional theory and dynamic capabilities theory (DCT), the study examines how sandbox environments enable firms to build technological and organizational capabilities that support responsible experimentation and long-term competitiveness. By comparing three national contexts: The UK, Japan, and Kenya. This research contributes to understanding how regulatory sandboxes shape the interaction between innovation, regulation and institutional evolution in the digital era.

2. Objectives

The objectives of this study are to:

1) Identify how regulatory sandboxes function as institutional catalysts that facilitate AI-driven BMI through flexibility, learning and adaptive governance.
2) Examine how variations in sandbox design, governance structure, and institutional maturity across the UK, Japan, and Kenya influence organizational learning, legitimacy building and capability development.
3) Compare cross-national sandbox models to evaluate how contextual factors such as policy orientation, state involvement, and regulatory flexibility shape the outcomes of AI experimentation.
4) Provide actionable policy recommendations that can guide regulators and policymakers in designing sandbox frameworks that promote responsible AI experimentation and institutional transformation.

3. Theoretical background

3.1. Institutional theory and dynamic capabilities theory

Institutional theory asserts that organisations operate within institutional environments that shape their structures, practices, and meanings rather than acting solely on the basis of technical efficiency or performance outcomes (Meyer and Rowan, 1977). Institutions are composed of regulative, normative, and cognitive pillars that provide stability, legitimacy, and shared meaning to organisational behaviour (Glynn and D'Aunno, 2023). Within these environments, formal structures often serve ceremonial functions to signal conformity with socially accepted norms and expectations, allowing organisations to maintain legitimacy even when their practices deviate from purely rational efficiency (Meyer and Rowan, 1977). As organisations interact within the same institutional fields, they tend to become more similar through coercive, mimetic, and normative mechanisms that generate institutional isomorphism and collective rationality (DiMaggio and Powell, 1983). Institutional theory further recognises that organisations are embedded in complex institutional contexts characterised by multiple, and sometimes conflicting, institutional logics that create both constraints and opportunities for strategic action (Greenwood et al., 2011). In such contexts, organisations engage in selective coupling or hybridisation of

institutional logics to manage competing demands and maintain legitimacy while pursuing innovation (Greenwood et al., 2011). Institutional change arises from these interactions and evolves through processes of layering, displacement, and reinterpretation of existing norms and practices (Micelotta et al., 2017). Rather than viewing institutions as static, contemporary perspectives emphasise their dynamic nature, where change results from the interplay between agency, power, and contextual contingencies (Micelotta et al., 2017; Glynn and D'Aunno, 2023). From this viewpoint, institutions are both constraining and enabling, as they limit organisational behaviour through rules and norms while simultaneously providing the legitimacy and frameworks necessary for innovation capability (Greenwood et al., 2011; Glynn and D'Aunno, 2023).

Building upon the institutional perspective that highlights how organizational actions are embedded within social and regulatory contexts, DCT provides a complementary lens for understanding how firms actively adapt and reconfigure their resources to respond to institutional and technological change (Teece et al., 1997). DCT emphasizes that superior performance arises not merely from possessing valuable resources but from the capacity to sense new opportunities, seize them effectively, and transform resource bases to maintain competitiveness. Eisenhardt and Martin (2000) identified dynamic capabilities as specific, learnable and replicable processes such as product development, strategic decision making, and knowledge integration that enable continuous adaptation in changing environments. These capabilities are often conceptualized as multidimensional, encompassing adaptive, absorptive, and innovative capacities that determine how firms achieve agility and strategic flexibility (Wang and Ahmed, 2007). Later, Teece (2007) proposed that managerial cognition, organizational learning, and coordination routines form the foundation that links dynamic capabilities to sustainable performance. In addition, Teece (2018) extended the theory to explain how dynamic capabilities underpin business model innovation and transformation, especially under conditions of digital disruption.

The integration of institutional theory and DCT provides a comprehensive foundation for analyzing how firms innovate and transform within evolving regulatory and technological contexts. Institutional theory emphasizes the role of formal and informal rules, norms, and belief systems that confer legitimacy and structure organizational behavior, yet its focus on conformity limits explanatory power in dynamic environments (Meyer and Rowan, 1977; DiMaggio and Powell, 1983). DCT addresses this limitation by explaining how firms build, integrate, and reconfigure resources to sense opportunities, seize them effectively, and re-align their operations in response to institutional and market shifts (Teece, 2007). Accordingly, this study conceptualizes the regulatory sandbox as an institutional mechanism that creates a controlled environment for experimentation and learning, enabling organizations to navigate regulatory uncertainty while enhancing dynamic capabilities through iterative adaptation and feedback (Gomber et al., 2018). BMI functions as the operational process that connects this institutional flexibility with firm-level transformation, allowing organizations to redesign value creation, delivery, and capture. (Clauss, 2017). The integration of these theories provides a coherent rationale for the conceptual model: the regulatory sandbox acts as the institutional catalyst, dynamic capabilities represent the adaptive mechanisms, BMI serves as the transformational process, and sustainable digital performance emerges as the realized outcome (Greenwood et al., 2011; Teece, 2018; Glynn and D'Aunno, 2023).

3.2. Regulatory sandbox

A regulatory sandbox is defined as a controlled experimental environment established by regulatory authorities to allow firms to test innovative products, services or business models under a temporary relaxation of existing regulatory requirements while remaining under regulatory oversight (Chen and Taeihagh, 2025; Cornelli et al., 2024). Emerging first in the United Kingdom through the Financial Conduct Authority, the sandbox framework has since been adopted globally as an adaptive policy tool that reconciles innovation with risk management in digital and financial ecosystems (Kálmán, 2025). As a governance innovation, the regulatory sandbox represents a paradigm shift from rule-based compliance to a learning-oriented regulatory model grounded in co-creation, experimentation, and iterative adaptation (Ford and Ashkenazy, 2025). Within this experimental setting, firms are encouraged to test new technologies such as AI, blockchain and digital finance solutions in a controlled setting where regulators can observe, evaluate, and learn from real-world performance before full-scale

market implementation (Johnson, 2022; Gumbo and Chude-Okonkwo, 2025). The sandbox thus functions not merely as a mechanism for regulatory relief but as an institutional interface that promotes collaboration, mutual learning, and trust-building between public and private stakeholders (Ford and Ashkenazy, 2025; Alaassar et al., 2020). Beyond its regulatory utility, the sandbox serves three interrelated purposes: regulatory learning, innovation facilitation and legitimacy enhancement (Gumbo and Chude-Okonkwo, 2025). The regulatory sandbox operates as an institutional mechanism that fosters trust, collaboration and adaptive capability among stakeholders, bridging the gap between innovation dynamics, regulatory legitimacy and serves as an institutional openness to innovation (Chen and Taeihagh, 2025; Goo and Heo, 2020).

Regulatory sandbox presents a multi-stage process composed of three core phases: initiation, implementation and graduation/closure (Chen and Taeihagh, 2025). In the initiation phase, regulators define the sandbox's objectives, eligibility criteria and governance structures, laying the institutional foundation for experimentation. In this stage the sandbox serves as an institutional signal, indicating regulatory flexibility and stakeholder engagement, thereby reducing entry barriers and establishing legitimacy for participating firms. The implementation phase involves active testing of innovative products or business models under controlled conditions, during which real-time monitoring, feedback loops and adaptive regulation take place. Here the sandbox functions as a learning platform where regulators and firms co-create knowledge, adjust regulatory parameters and build dynamic capabilities for adaptation to novel technologies. Finally, the graduation/closure phase addresses the transition from sandbox to full market deployment or regulatory normalisation, including mechanisms for scaling, exit criteria and post-sandbox monitoring. In this phase the sandbox helps firms reconfigure their business models and embed innovations into the mainstream, while regulators capture lessons and institutionalise new regulatory practices. Across these phases, the sandbox plays three pivotal roles: as a legitimacy-enhancing mechanism, as a capability-building accelerator and as a scaling-and-diffusion enabler for innovation (Chen and Taeihagh, 2025).

3.3. Artificial intelligence and business model innovation

Multiple definitions of AI coexist in the academic literature, reflecting its interdisciplinary and evolving nature (Mariani et al., 2023; Bahoo et al., 2023). This study adopts the widely accepted understanding of AI as a system's ability to correctly interpret external data, learn from such data and apply acquired knowledge to achieve specific goals through adaptive behavior (Kaplan and Haenlein, 2019). AI encompasses a broad range of computational techniques that simulate cognitive processes such as perception, reasoning, and learning, enabling machines to perform tasks that typically require human intelligence (Soni et al., 2020). Scholars often classify AI according to its level of intelligence, distinguishing between narrow AI, which performs specific tasks, and general AI, which aspires to human-like cognition (Kaplan and Haenlein, 2019). Mariani et al. (2023) emphasize functionality, differentiating among assisted, augmented and autonomous intelligence based on the degree of human involvement in decision making. AI represents an umbrella concept that integrates data processing, machine learning, and adaptive algorithms to enhance analytical precision, automate complex reasoning, and expand the boundaries of human capability (Soni et al., 2020; Bahoo et al., 2023).

BMI is increasingly recognized as a continuous transformational process in which sustainable competitive advantage arises not only from technological progress but also from the reconfiguration of business models to meet the challenges of globalization, digitalization, and evolving market demands (Teece, 2010; Zott and Amit, 2010). It represents both a strategic outcome and a dynamic mechanism for organizational renewal that enables firms to continuously adapt their structures and processes in response to environmental change (Wirtzet al., 2016). As the purposeful redesign of interrelated activity systems encompassing products, services, technologies, and information flows beyond the focal firm's boundaries, BMI allows organizations to translate technological advancements into mechanisms of value creation and value capture while optimizing relationships across the value network (Zott and Amit, 2010; Baden-Fuller and Haefliger, 2013). Clauss (2017) further conceptualized BMI as comprising three interdependent dimensions: value creation, value proposition, and value

capture. Consequently, BMI plays a central strategic role in driving innovation, resilience, and long-term competitiveness in an increasingly global and volatile business landscape (Teece, 2010; Clauss, 2017).

3.4. AI–driven BMI

AI-driven BMI refers to the intentional transformation of value creation, delivery and capture mechanisms through the application of AI technologies that learn, predict, and adapt to changing environments (Foss and Saebi, 2017; Enholm et al., 2022). AI enables the systematic reconfiguration of business models by processing large data sets, generating insights and supporting decision-making processes that enhance organizational responsiveness and innovation capability (Lee et al., 2019). The integration of AI promotes continuous adaptation and experimentation by allowing firms to align their structures with technological and market dynamics, leading to the emergence of novel value propositions and digital revenue architectures (Sjödin et al., 2021). AI functions as both an enabler and a driver of business model renewal, facilitating automation, personalization and predictive intelligence that transform how organizations create and deliver value (Loureiro et al., 2021; Åström et al., 2022). The implementation of AI further generates feedback loops that reinforce learning and co-evolution between human expertise and algorithmic intelligence, producing scalable and adaptive business models (Kanbach et al., 2024). This conceptualization positions AI-driven BMI as a transformative mechanism through which artificial intelligence transcends its technical function to become a central force of organizational renewal, redefining competitiveness and innovation in the digital economy (Jorzik et al., 2024; Enholm et al., 2022).

As outlined above, AI-driven BMI involves an iterative and data-intensive process through which organizations leverage artificial intelligence to explore, experiment, and exploit new opportunities for value generation (Sjödin et al., 2021). The continuous feedback between data analytics, algorithmic learning, and managerial decision-making establishes a co-evolutionary mechanism that accelerates the transformation of business models (Jorzik et al., 2024). In this process, AI capabilities provide firms with predictive insights and cognitive augmentation that support the redesign of activity systems and the creation of dynamic configurations of value networks (Åström et al., 2022). Recent studies highlight that AI not only enhances operational efficiency but also enables the development of adaptive, intelligent and ecosystem-oriented business models capable of evolving with external technological and institutional changes (Kanbach et al., 2024; Loureiro et al., 2021). The transformative power of AI lies in its ability to combine automation, learning, and creativity, turning data into strategic intelligence that reshapes organizational boundaries and innovation trajectories (Lee et al., 2019). Through these mechanisms, AI-driven BMI redefines how firms conceptualize, structure and scale innovation within the digital economy (Enholm et al., 2022).

3.5. How regulatory sandboxes enables AI–driven BMI

Regulatory sandboxes create institutional conditions that facilitate the emergence and scaling of AI-driven BMI by combining regulatory flexibility with structured oversight (Chen and Taeihagh, 2025). As adaptive policy laboratories, sandboxes allow firms to test AI-enabled solutions in controlled environments where regulatory requirements are temporarily relaxed, reducing institutional uncertainty and compliance risks (Gomber et al., 2018; Ford and Ashkenazy, 2025). This institutional experimentation supports the development of organizational learning and feedback mechanisms that enable firms to better understand regulatory expectations, ethical constraints, and technological boundaries. By fostering open dialogue between innovators and regulators, the sandbox functions as a collaborative governance platform that legitimizes the use of emerging technologies while promoting responsible innovation. The flexibility provided through sandbox participation enhances firms' ability to sense opportunities, seize resources, and reconfigure value systems, reflecting the core logic of dynamic capabilities (Teece, 2007; Greenwood et al., 2011).

The enabling role of regulatory sandboxes in AI-driven BMI extends beyond regulatory relief to institutional capability building. Through iterative experimentation, firms participating in sandboxes develop a deeper understanding of how AI can be applied to reconfigure value creation, delivery, and capture mechanisms

(Sjödin et al., 2021; Clauss, 2017). The structured testing phases of the sandbox ranging from entry selection to live experimentation and graduation create feedback loops that accelerate both technological learning and business model transformation (Chen and Taeihagh, 2025). These processes cultivate absorptive and adaptive capabilities that allow firms to transfer knowledge gained in the sandbox to real market contexts, scaling AI solutions into viable, data-driven business models (Åström et al., 2022; Kanbach et al., 2024). In turn, regulators benefit from policy learning that enhances institutional responsiveness and supports the codification of best practices for emerging technologies. The sandbox thus operates as an institutional catalyst that aligns experimentation, capability development, and regulatory evolution, creating a mutually reinforcing cycle that drives AI-driven BMI and contributes to sustainable digital transformation (Gumbo and Chude-Okonkwo, 2025; Jorzik et al., 2024).

4. Methodology

4.1. Data collection and case selection

Data for this study were collected through an extensive review of secondary sources, including policy reports, institutional documents, academic literature, and publicly available databases such as the Datasphere Initiative, OECD policy briefs, and national regulatory agency publications. This approach ensures a comprehensive understanding of how different jurisdictions conceptualize and operationalize AI related sandboxes within their innovation ecosystems. Case selection followed a purposive sampling strategy guided by theoretical relevance and representativeness. Three countries, the UK, Japan and Kenya, were selected to capture variation across levels of economic development, institutional maturity, and policy orientation. The UK represents an advanced economy with a mature co- regulatory framework emphasizing ethical AI governance. Japan reflects a state led innovation system integrating sandboxing into industrial policy, while Kenya exemplifies a developing context where sandboxes serve as instruments for capacity building and financial inclusion.

4.2. Data analysis and synthesis

The analysis followed a structured process of qualitative synthesis combining descriptive mapping, thematic coding, and comparative interpretation. First, descriptive data from policy documents and institutional sources were organized into a global dataset summarizing the distribution, type and thematic focus of AI related sandboxes. Second, thematic analysis was used to identify recurring patterns related to institutional design, regulatory flexibility, and innovation outcomes. These themes were then interpreted through the lens of institutional theory and DCT to uncover how sandboxes function as mechanisms of organizational learning and legitimacy building. Finally, cross case comparison was conducted to identify convergences and divergences among the selected countries. Through this integrative approach, the study bridges conceptual theorization with empirical observation, generating insights into how adaptive regulatory environments shape technological transformation in diverse economic and institutional settings.

5. Findings

5.1. Overview of global sandbox for AI innovation

The global landscape of regulatory sandboxes has evolved into a critical institutional mechanism for fostering responsible innovation in AI and data-driven technologies. As of January 2025, research by the Datasphere Initiative reveals that there are 66 sandboxes worldwide related to data, AI, or technology, of which 59 are national sandboxes and 7 operate at global, regional, state or municipal levels (Datasphere Initiative, 2025). Among these, 31 sandboxes are specifically designed to foster AI innovation, focusing on domains such as machine learning, AI development and data-driven solutions. The diffusion of sandbox initiatives reflects a growing international consensus that policy experimentation is indispensable for addressing regulatory uncertainty and enabling technological advancement in complex and dynamic digital ecosystems (Chen and Taeihagh, 2025; Ford and Ashkenazy, 2025). At least 44 countries have implemented or are developing national sandbox programs, with 23 countries actively planning or operating AI-specific sandboxes, underscoring the rapid institutionalisation of sandbox frameworks as instruments of adaptive governance (Datasphere Initiative, 2025).

These initiatives not only act as testing grounds for AI innovation but also as policy laboratories that facilitate iterative learning, stakeholder engagement, and the co-evolution of regulation and technology (Gumbo and Chude-Okonkwo, 2025).

Table 1 Global Overview of Data, AI and Technology Sandboxes

Indicator	Value	Description
Total sandboxes worldwide	66	Encompass data, AI, and broader technology-focused regulatory or operational environments
National sandboxes	59	Operated at the national level under government or regulatory agencies
Regional / Global / State / Municipal sandboxes	7	Sub-national or cross-border initiatives supporting localized or collaborative experimentation
AI-specific sandboxes	31	Designed to advance machine learning, AI applications, and data-driven innovation
Countries with sandbox initiatives	44	Have implemented or are developing national sandbox frameworks
Countries with AI-specific sandboxes (active/planned)	23	Actively operating or planning sandboxes dedicated to AI experimentation

Source: Authors compilation, 2025

Originally developed to enable safe experimentation with financial innovations, the sandbox model has been progressively extended to domains such as data governance, digital platforms and emerging technologies, where the pace of innovation exceeds the capacity of existing regulatory systems (Chen and Taeihagh, 2025). Over time, these frameworks have diversified in both purpose and structure, resulting in three primary typologies: regulatory, operational and hybrid sandboxes. Each of these models embodies distinct institutional logics: Regulatory sandboxes focus on compliance learning and adaptive oversight; Operational sandboxes emphasize experimentation through data access and technical collaboration; Hybrid sandboxes integrate both objectives within a shared ecosystem. This tripartite classification underscores the multifunctional nature of sandboxes as institutional laboratories, enabling policy learning, regulatory innovation, and cross-sectoral cooperation.

Regulatory sandboxes embody a form of institutionalized experimentation that transforms regulation into a dynamic, feedback-driven process rather than a static compliance mechanism. Operating as structured environments where innovators and regulators co-produce knowledge, enabling both sides to understand technological implications and refine oversight mechanisms through iterative interaction (Ford and Ashkenazy, 2025). This collaborative governance model reduces information asymmetry and enhances regulatory agility by allowing adjustments to rules and procedures based on empirical evidence generated during testing (Chen and Taeihagh, 2025). Beyond their procedural utility, regulatory sandboxes serve as policy learning infrastructures, providing real-time insights into the market, technology, and behavioral responses that traditional consultation methods fail to capture. Through these mechanisms, they enable regulators to anticipate risks and design proportionate interventions while granting firms the flexibility to align innovation trajectories with compliance expectations. Some sandboxes emphasize alignment and procedural streamlining while others adopt a more experimental orientation, temporarily relaxing specific regulatory constraints to stimulate scientific and industrial innovation (Gumbo and Chude-Okonkwo, 2025). Regulatory sandboxes institutionalize a negotiated balance between innovation and legitimacy, ensuring that emerging technologies can be tested safely, transparently and adaptively before large-scale deployment.

Operational sandboxes represent the data and experimentation dimension of institutional innovation, providing structured and secure environments for testing data-driven solutions under controlled conditions (OECD, 2023). Their primary objective is to enable collaboration among regulators, enterprises, and research actors to jointly explore emerging technologies while ensuring accountability and transparency in data use. By facilitating access to shared datasets and analytical resources, operational sandboxes allow participants to identify new applications of data, improve algorithmic performance, and strengthen the governance mechanisms required for responsible digital transformation (Gumbo and Chude-Okonkwo, 2025). At a systemic level, operational sandboxes act as institutional learning infrastructures that support continuous adaptation and regulatory responsiveness. They generate empirical insights that help policymakers refine data governance standards, ethical guidelines, and interoperability frameworks based on practical experimentation (OECD, 2023). Operational sandboxes contribute to building institutional capacity by integrating innovation with evidence-based governance, thereby aligning technological advancement with social responsibility and public value. Through iterative learning and controlled testing, operational sandboxes bridge the gap between data policy and innovation ecosystems by transforming data collaboration into a process of institutional co-creation (Chen and Taeihagh, 2025; Gumbo and Chude-Okonkwo, 2025).

Hybrid sandboxes integrate the regulatory and operational dimensions of experimentation, combining rule adaptation with data collaboration to create environments where innovation and governance co-evolve (Chen and Taeihagh, 2025). They provide an institutional architecture in which regulatory flexibility is balanced with technical and ethical safeguards, enabling innovators to test emerging technologies while regulators observe and adjust policy parameters in real time (OECD, 2023). This dual structure allows hybrid sandboxes to serve both as compliance laboratories and as collaborative platforms for data-driven exploration, linking regulatory oversight with innovation learning cycles. Hybrid sandboxes embody an adaptive model of institutional design that promotes coordination between policy agencies, industry actors, and research institutions. They enhance coherence across fragmented regulatory domains by aligning legal experimentation with data governance and digital ethics frameworks. Through this mechanism, hybrid sandboxes help regulators develop anticipatory capacities, ensuring that regulatory systems remain responsive to technological change while safeguarding societal interests (Gumbo and Chude-Okonkwo, 2025). These sandboxes produce outcomes that transcend immediate innovation testing by generating institutional learning, improve interoperability between regulatory and technological infrastructures, and accelerate the translation of experimental insights into long-term policy reform (Chen and Taeihagh, 2025). By merging flexibility with accountability, hybrid sandboxes operationalize a balanced approach to innovation governance, establishing them as pivotal instruments for fostering responsible and sustainable digital transformation (OECD, 2023).

By early 2025, 23 countries had either implemented or were in the process of developing national sandboxes specifically dedicated to AI, amounting to a total of 31 initiatives worldwide. Among these, regulatory sandboxes account for the vast majority, with 24 cases, while only two are operational and five are hybrid or uncategorized. This distribution underscores a strong policy inclination toward using regulatory mechanisms as the primary channel for guiding AI experimentation and governance. The dominance of regulatory sandboxes indicates that governments increasingly view controlled policy environments as essential instruments for mitigating risk, enhancing oversight, and legitimizing AI deployment before market diffusion. The relative scarcity of operational and hybrid sandboxes suggests that most jurisdictions are still in the early stages of integrating technical data infrastructures with adaptive governance frameworks. Nonetheless, the presence of hybrid models signals a growing recognition of the need to bridge compliance-oriented approaches with collaborative, data-driven experimentation.

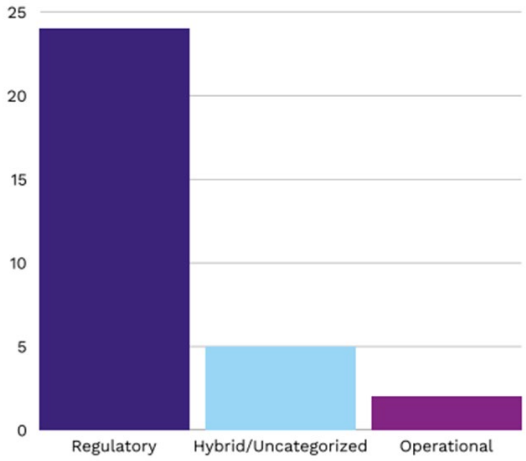

Figure 1 National types of AI sandboxes

Source: Datasphere Initiative, 2025

As of January 2025, AI and data-related sandboxes have been implemented across more than twenty countries, spanning Europe, Asia, the Americas, and Oceania. This spatial dispersion underscores a widening policy convergence toward structured experimentation as a core component of national and regional digital strategies. Advanced economies such as the United Kingdom, Singapore, and Australia have established multiple sandboxes that act as testbeds for AI-driven regulatory reform, while emerging economies including Colombia, Kenya, and Malaysia have begun to adopt sandbox models to stimulate digital capacity building and institutional learning. An important trend in this landscape is the emergence of cross-border and regional sandboxes, designed to foster cooperation among jurisdictions and harmonize regulatory approaches. The European Union's Metis Sandbox exemplifies this movement by enabling interoperability testing of datasets across the EU's digital infrastructure, ensuring alignment with metadata and data quality standards. Such collaborative mechanisms not only improve data aggregation and transparency but also reduce duplication in compliance processes, facilitating smoother policy coordination across borders (OECD, 2023). This model demonstrates how sandboxing has evolved from a national innovation tool into a platform for transnational governance experimentation, allowing countries to collectively test, refine, and scale AI regulations. The global proliferation of AI sandboxes reveals a dynamic institutional diffusion process in which nations learn from one another's experimental designs, adapting sandbox frameworks to their own regulatory and developmental contexts. Growing presence of regional and cross-border initiatives reflects a shift toward networked governance, where innovation ecosystems are shaped through shared standards, mutual learning, and collective accountability.

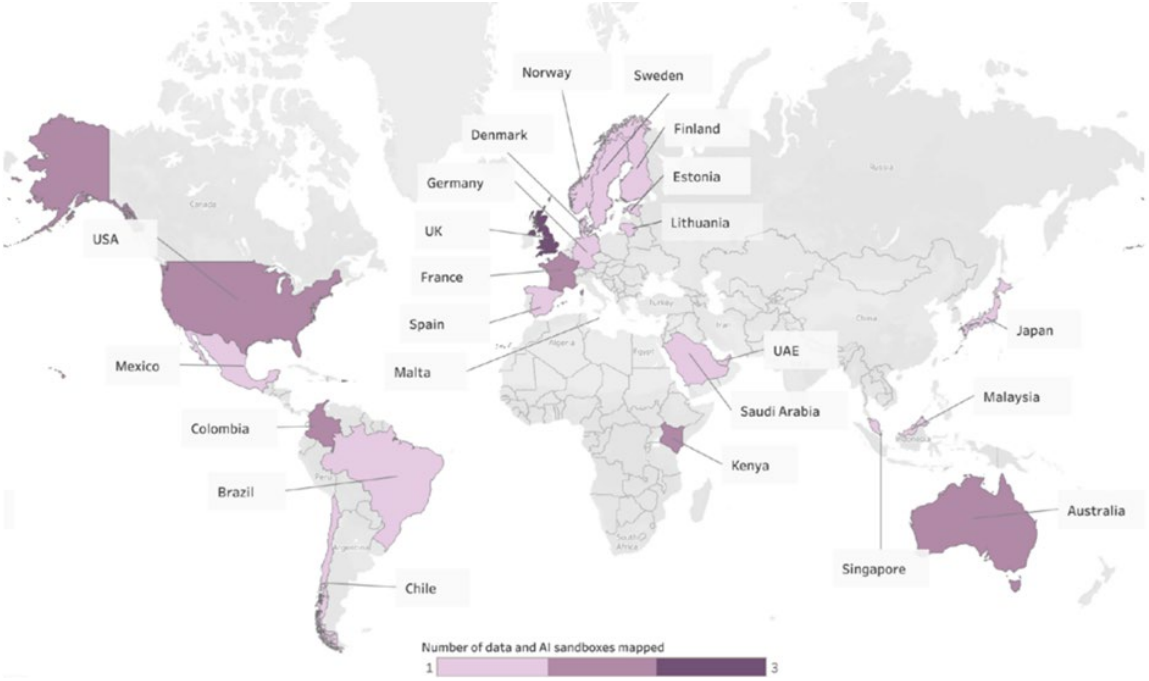

Figure 2 Sandboxes for AI innovation around the world

Source: Datasphere Initiative, 2025

5.2. Global case studies of AI sandboxes

Building upon the global overview of AI sandbox implementation, this section examines concrete national initiatives to understand how different jurisdictions operationalize sandbox mechanisms to foster responsible AI innovation. While the global mapping reveals broad diffusion across continents, each region exhibits distinct institutional logics, regulatory objectives, and technological priorities that shape the design and operation of sandboxes. To contextualize these variations, Table 2 summarizes the distribution of national AI sandboxes by region, highlighting their dominant regulatory models, functional orientations, and thematic focus areas. This comparative perspective provides a foundation for analyzing how sandboxes function as institutional laboratories that balance innovation with oversight in diverse socio-technical environments.

Table 2 National sandboxes for AI innovation around the world

Region	Countries	Total	Regulatory	Operational	Hybrid
Europe	Denmark, Estonia, Finland, France, Germany, Lithuania, Malta, Norway, Spain, Sweden, United Kingdom	14	10	1	3
Asia–Pacific	Australia, Japan, Malaysia, Singapore	7	5	0	2
Americas	Brazil, Chile, Colombia, Mexico, United States	6	4	2	0

Region	Countries	Total	Regulatory	Operational	Hybrid
Middle East and Africa	Kenya, Saudi Arabia, United Arab Emirates	4	4	0	0
Total	**23**	**31**	**23**	**3**	**5**

Source: Authors compilation, 2025

To explore how regulatory sandboxes function across different institutional contexts, this section examines three representative national cases: the UK, Japan, and Kenya. These countries were selected to reflect diverse stages of economic and institutional development. The comparative analysis captures how sandbox mechanisms evolve from facilitating ethical compliance in advanced economies to fostering institutional learning and capacity building in developing contexts.

5.3. The UK

The UK has established one of the most comprehensive and institutionalized systems of regulatory sandboxes in the world, positioning itself as a global leader in adaptive governance for emerging technologies. Initially introduced by the Financial Conduct Authority, the sandbox was designed as a supervised experimental environment that allows organizations to test new products, services, or algorithms under relaxed regulatory conditions while maintaining oversight. Over time, this approach has been expanded to include artificial intelligence, data governance and digital ethics, with the Information Commissioner's Office and the Medicines and Healthcare Products Regulatory Agency taking leading roles. Within these sandboxes, firms collaborate directly with regulators to refine technical solutions, compliance mechanisms, and ethical frameworks before products enter the market. This co-regulatory model transforms regulation from a static rule-based system into a dynamic process of learning and feedback, enhancing both regulatory agility and institutional capacity. The UK's sandbox ecosystem plays a critical role in promoting safe experimentation and fostering trust between innovators, government agencies and the public. Providing a structured pathway for testing AI systems that involve complex data processing, automated decision-making, or sensitive ethical implications such as fairness and accountability.

By enabling early-stage engagement with regulators, the sandbox helps innovators anticipate compliance challenges and align design processes with emerging AI governance standards. The UK's sandbox functions as both an innovation accelerator and a risk management tool, supporting the government's broader strategy to maintain technological competitiveness while ensuring public protection. However, the UK model still faces structural limitations. Participation remains largely confined to established enterprises and research consortia capable of meeting technical and legal requirements, which restricts access for startups and smaller innovators. Moreover, while the focus on privacy and data protection has strengthened public trust, it has also narrowed the scope for testing AI applications in other high-impact areas such as predictive analytics, generative systems, and autonomous operations. Despite these constraints, the UK sandbox framework demonstrates how a well-designed regulatory instrument can institutionalize experimentation, embed ethical oversight and support the strategic integration of AI into national innovation and governance systems.

5.4. Japan

Japan has positioned its regulatory sandbox system as a central instrument of national innovation policy, reflecting a government driven approach to balancing technological advancement and regulatory flexibility. Introduced in 2018 under the Cabinet Secretariat's New Form of Capitalism agenda, the Japanese sandbox serves as a strategic platform where companies, research institutions, and ministries collaborate to test emerging technologies including artificial intelligence, robotics, digital finance, and healthcare innovations without the immediate burden of full regulatory compliance. Unlike many Western models that emphasize sector specific regulation, Japan's sandbox adopts a cross sectoral and problem oriented design, allowing any industry to apply

for temporary regulatory exemptions if the proposed experiment demonstrates potential social or economic benefit.

This mechanism embodies the country's institutional philosophy of coordinated innovation, where the state acts not merely as a regulator but as an enabler of technological transformation. The sandbox provides a structured framework through which firms can submit proposals, receive government approval, and conduct time bound experiments under close monitoring. Regulatory agencies observe, collect data and adapt existing laws based on experimental outcomes, transforming the sandbox into a feedback loop that aligns governance with rapid technological evolution. In the context of artificial intelligence, the sandbox has been instrumental in advancing the development of AI applications in smart mobility, precision medicine and industrial automation. Providing a policy space for firms to test algorithms that require real world validation such as image recognition, machine learning based diagnostics, and autonomous decision systems while ensuring accountability through ethical review and risk assessment procedures.

Beyond fostering innovation, Japan's sandbox plays a crucial role in supporting industrial policy objectives, particularly the creation of a digital economy grounded in public trust and social acceptance. By enabling regulatory flexibility, the system encourages public private partnerships, accelerates commercialization, and strengthens Japan's competitiveness in global technology markets. However, several challenges persist. The process for sandbox approval can be bureaucratically intensive, requiring coordination across multiple ministries, which may slow down the pace of experimentation. Moreover, while the framework promotes innovation, it remains heavily centralized with limited participation from startups and regional actors who often lack the institutional capacity to engage in formal experimentation. Consequently, the Japanese sandbox system illustrates both the potential and constraints of state led innovation governance, effective in fostering national technological leadership but still evolving toward greater inclusivity, agility, and responsiveness to the diverse needs of AI driven enterprises.

5.5. Kenya

Kenya represents an emerging example of how regulatory sandboxes can serve as instruments of digital transformation and financial inclusion in developing economies. The country introduced its first regulatory sandbox through the Capital Markets Authority, followed by another under the Communications Authority, as part of a broader national strategy to foster innovation within the financial technology and information and communication technology sectors. These sandboxes provide a supervised environment in which firms can test new technologies such as artificial intelligence enabled financial services, mobile payment systems, and digital identity solutions while working closely with regulators to ensure compliance and consumer protection. This framework reflects Kenya's institutional ambition to position itself as a regional leader in technology governance by combining regulatory oversight with developmental objectives.

The sandbox has evolved into a strategic governance tool that integrates learning, adaptation and capacity building into the national innovation system. Performing a dual function by simultaneously enabling market experimentation and managing systemic risks. For regulators, the sandbox serves as a real time observatory for understanding the social and economic implications of emerging technologies before they reach mass adoption. For innovators, the sandbox reduces regulatory uncertainty and lowers entry barriers, particularly for startups seeking to deploy AI based solutions in financial services, agriculture or small business lending. In this process, the sandbox nurtures new business models and strengthens Kenya's position as a hub for inclusive digital finance in Africa.

Kenya's experience illustrates how a developing economy can localize global innovation frameworks while embedding them within its socio economic priorities. The sandbox approach has encouraged collaboration across ministries, development partners and private sector actors, creating a shared platform for experimentation and knowledge exchange. By linking innovation policy to capacity building and stakeholder participation, the Kenyan model promotes both legitimacy and learning in digital governance. Nonetheless, challenges remain substantial. Limited technical expertise, fragmented coordination among agencies, and uneven infrastructure

constrain the system's scalability and effectiveness. Despite these constraints, Kenya's regulatory sandbox demonstrates the potential of adaptive governance to align technological innovation with social inclusion, thereby advancing a distinctly African pathway toward sustainable digital transformation.

5.6. Cross-case comparative analysis

The comparative analysis of regulatory sandboxes in the United Kingdom, Japan, and Kenya reveals how contextual factors such as economic development, institutional maturity, and policy orientation shape the design and impact of sandbox governance models. While all three countries share the objective of balancing innovation with risk management, their approaches differ significantly in scope, governance structure, and strategic intent. The United Kingdom's model emphasizes co-regulation and trust building through collaborative experimentation, Japan's framework reflects a state led approach rooted in national industrial policy, and Kenya's experience demonstrates the adaptive potential of sandboxing as a tool for inclusive development. These cases illustrate that sandbox mechanisms are not uniform instruments but context sensitive frameworks whose effectiveness depends on institutional capacity, political will and inclusivity in governance processes.

Table 3 Comparative overview of AI Sandboxes: The UK, Japan, and Kenya

Dimension	United Kingdom	Japan	Kenya
Institutional design	Decentralized and collaborative, led by the Information Commissioner's Office and supported by multiple agencies and private partnerships.	Centralized under the Cabinet Secretariat, integrating multiple ministries within a national innovation framework.	Semi centralized, led by the Capital Markets Authority and Communications Authority with donor and industry collaboration.
Policy orientation	Focused on ethical AI development, data protection and responsible innovation aligned with human centric governance.	Emphasizes industrial competitiveness, productivity enhancement and economic modernization under the New Form of Capitalism agenda.	Aims to promote financial inclusion, digital entrepreneurship and technology adoption for socio economic development.
Regulatory flexibility	High procedural flexibility allowing firms to test within adjusted compliance rules and limited legal exposure.	Moderate flexibility with close government oversight and time bound experimentation.	Moderate to low flexibility, focused on guided experimentation and capacity building for local innovators.
State role and governance style	The state acts as facilitator and co regulator, enabling trust and transparency through stakeholder engagement.	The state acts as planner and enabler, directing technological priorities through coordinated industrial policy.	The state acts as catalyst and supporter, integrating innovation with development goals and public private collaboration.
Key strengths	Mature institutional environment, clear ethical standards and strong regulatory expertise.	Strong policy coherence, long term innovation strategy and integration across sectors.	Inclusive approach to financial innovation, developmental focus and alignment with local

Dimension	United Kingdom	Japan	Kenya
			needs.
Main challenges	Limited scalability beyond pilot projects and dependence on regulatory resources.	Bureaucratic complexity, limited startup participation, and centralized decision making.	Resource constraints, uneven institutional capacity and fragmented coordination between agencies.

Source: Authors compilation, 2025

The cross case comparison highlights a continuum of regulatory innovation: the UK's collaborative and ethics driven governance, Japan's policy directed model of industrial coordination and Kenya's inclusive and adaptive experimentation framework. These approaches reveal that the success of AI sandboxes relies not only on regulatory design but also on institutional learning, cross sectoral partnerships and the ability to align innovation with social and economic priorities.

6. Discussion and conclusion

6.1. Theoretical implications

This study contributes to institutional theory and DCT by conceptualizing the regulatory sandbox as an institutional catalyst that embeds experimentation and learning within the process of business model innovation. Existing literature in institutional theory primarily emphasizes how organizations conform to regulatory pressures and normative expectations to gain legitimacy. However, the cases of the United Kingdom, Japan, and Kenya demonstrate that institutions can also operate as platforms for change and adaptive learning. The regulatory sandbox exemplifies a form of institutional entrepreneurship where the state reconfigures its role from enforcing compliance to enabling innovation through structured flexibility. This finding extends institutional theory by illustrating how regulatory mechanisms can evolve into active governance infrastructures that promote institutional openness, coordination, and reflexivity rather than mere constraint.

The comparative analysis further reveals that the institutional design of sandboxes determines the nature of dynamic capabilities that firms develop. In co-regulatory environments such as the United Kingdom, firms enhance their sensing and seizing capabilities through close interaction with regulators and multi-stakeholder networks. In Japan's state-led framework, dynamic capabilities emerge through coordinated adaptation, where firms align innovation with national industrial priorities. In Kenya's developmental model, the sandbox fosters absorptive and adaptive capabilities that help firms translate AI-driven experimentation into socially embedded business models. These variations indicate that dynamic capabilities are not only firm-specific but institutionally conditioned, shaped by the regulatory and cultural context in which learning occurs.

By integrating institutional and DCT perspectives, this study advances theoretical understanding of how innovation governance mechanisms influence the trajectory of organizational transformation. The sandbox functions as a meso-level institutional interface that connects macro-level regulatory systems with micro-level organizational learning processes. Through iterative experimentation, feedback loops, and co-creation, it enables organizations to develop the strategic flexibility needed to navigate uncertainty and legitimacy pressures simultaneously. This insight bridges the gap between theories of institutional stability and organizational adaptation, showing that controlled institutional experimentation can serve as a generative mechanism of change.

The findings highlight that institutional structures do not merely constrain or enable firm behavior; they co-evolve with organizational capabilities and innovation outcomes. Regulatory sandboxes thus represent a new form of dynamic institution that embeds flexibility, learning and legitimacy within governance itself. This conceptualization reframes institutional theory for the digital era, suggesting that the future of organizational

innovation depends not only on technological advancement but also on the institutional architectures that structure how adaptation and experimentation occur.

6.2. Practical implications

The findings of this study offer several important implications for policymakers, regulators, and organizations seeking to advance responsible AI-driven innovation. First, the results highlight that the design of regulatory sandboxes must be aligned with the broader institutional and developmental context. One-size-fits-all approaches are unlikely to succeed, as each governance model reflects distinct national priorities, institutional capacities, and socio-economic objectives. Advanced economies such as the UK demonstrate the value of co-regulatory frameworks that integrate ethics, privacy, and accountability into the innovation process, while contexts such as Kenya reveal the importance of linking sandbox initiatives to capacity building, inclusion and digital infrastructure development. Policymakers should therefore view sandboxes not only as tools for regulatory experimentation but as policy infrastructures that support systemic learning and long-term institutional capability building.

Second, the study underscores the necessity of multi-stakeholder collaboration in sandbox governance. Effective sandboxes depend on continuous interaction among regulators, innovators, academia and civil society to ensure transparency, knowledge exchange, and social trust. This collaborative orientation transforms the sandbox into a governance ecosystem where public and private actors co-create adaptive norms and regulatory frameworks. Regulators can use these insights to design more participatory and feedback-driven policy processes, reducing information asymmetry and aligning technological innovation with societal values.

Third, the study provides guidance on how to strategically leverage sandbox participation to enhance dynamic capabilities. By engaging in sandbox experiments, organizations can strengthen their ability to sense emerging opportunities, seize new markets, and reconfigure resources in alignment with regulatory and ethical expectations. The sandbox setting encourages firms to embed compliance, data responsibility, and stakeholder dialogue into their business model innovation processes, transforming regulatory engagement from a constraint into a source of competitive advantage. This reinforces the view that responsible innovation and market success are not opposing objectives but mutually reinforcing outcomes of institutional learning.

Finally, governments and development agencies in emerging economies can adopt the sandbox model as a pragmatic mechanism for digital transformation. By embedding experimentation into national innovation systems, sandboxes can foster trust, attract investment and promote inclusive participation in the AI economy. In this way, regulatory sandboxes serve as both governance instruments and developmental infrastructures—enabling nations to navigate the complexities of AI governance while cultivating institutional agility, resilience, and social legitimacy.

6.3. Limitations and future research

While this study provides a conceptual and comparative understanding of how regulatory sandboxes function as institutional catalysts for AI-driven BMI, it is primarily based on secondary data and qualitative synthesis. As such, its findings are interpretive rather than causal. Future research should therefore pursue empirical investigation to assess the actual impact of sandbox participation on firm-level innovation performance, capability development, and regulatory adaptation. Quantitative or mixed-method approaches could be used to evaluate how different sandbox designs influence the emergence, scaling, and sustainability of AI-based business models across various institutional contexts. A promising direction would be to conduct longitudinal or cross-country studies comparing economies with different levels of regulatory maturity and state involvement. In advanced economies, sandboxes may operate as instruments of soft regulation that promote ethical and competitive innovation, whereas in emerging or developing contexts they may serve as mechanisms of institutional learning, capacity building, and market formalization. Empirical evidence is needed to determine whether sandboxes primarily function as independent enablers of innovation or as regulatory extensions of state policy. Such analysis could clarify how institutional autonomy, governance design and stakeholder composition

mediate the effectiveness of sandbox experimentation. Additionally, future research should examine the interaction between sandbox participation and firm-level dynamic capabilities. Investigating how organizations sense opportunities, seize resources and transform business models within sandbox environments would provide deeper insights into the micro-foundations of institutional learning and adaptation. Comparative case studies or survey-based research could also explore how sandbox outcomes differ across sectors such as finance, healthcare and mobility, where AI integration entails distinct ethical, technical and regulatory challenges.

7. References

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