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János Kálmán *

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The Role of Regulatory Sandboxes in FinTech Innovation: A Comparative Case Study of the UK, Singapore, and Hungary

János Kálmán

István Széchenyi University; kalman.janos@sze.hu

Abstract: The advent of regulatory sandboxes has emerged as a strategic policy instrument, with the objective of facilitating innovation in the financial technology (FinTech) sector, whilst ensuring the maintenance of regulatory oversight. These frameworks enable FinTech firms to experiment with new products and services in a controlled environment, thereby fostering experimentation and reducing the regulatory barriers to market entry. Despite the increasing global adoption of regulatory sandboxes, there is a paucity of empirical evidence on the actual impact of such initiatives on FinTech innovation and firm-level outcomes. The present study investigates the role of regulatory sandboxes in supporting FinTech development, with a specific focus on their influence on innovation processes and market entry dynamics. The present paper employs a qualitative multiple case study approach to examine three jurisdictions with distinct regulatory environments: namely, the United Kingdom, Singapore, and Hungary. These countries represent a range of regulatory maturity levels and sandbox design features, providing a substantial foundation for comparative analysis. The findings indicate that participation in a sandbox has a significant impact on firms' access to funding, the speed of product development, and long-term market integration. The United Kingdom and Singapore are exemplars of well-established regulatory ecosystems that are driven by innovation, while Hungary offers insights into the potential of the sandbox model in emerging markets. The present study contributes to the growing corpus of literature on the subject of FinTech regulation, and it provides policy-relevant recommendations for the optimisation of sandbox design in order to balance innovation and oversight.

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1. Introduction

The rapid evolution of financial technology (FinTech) has had a profound impact on the global financial landscape, giving rise to innovative products and services that challenge traditional financial systems. Nevertheless, these advancements frequently exceed the capacity of existing regulatory frameworks, engendering uncertainties that have the potential to impede innovation and market entry. In order to address this issue, regulatory sandboxes have been proposed as a novel approach, allowing FinTech firms to test their innovations in a controlled environment under the supervision of regulatory authorities.

The objective of regulatory sandboxes is to achieve a balance between the promotion of innovation and the assurance of consumer protection and financial stability. The provision of a structured framework for experimentation by these sandboxes has been demonstrated to reduce regulatory uncertainty, encourage investment, and facilitate the entry of new players into the financial market. The Financial Conduct Authority (FCA) of the United Kingdom was the first to establish this concept in 2016, thereby establishing a precedent that has since been adopted by numerous other jurisdictions worldwide, including Singapore and Hungary.

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Empirical studies have begun to shed light on the impact of regulatory sandboxes. For instance, Goo and Heo (2020) conducted a comparative analysis across nine countries and found that the introduction of regulatory sandboxes positively influenced FinTech venture investments, suggesting that such frameworks can play a vital role in enhancing the FinTech ecosystem. In a similar vein, Cornelli et al. (2024) presented evidence from the UK, indicating that firms participating in the sandbox exhibited a higher propensity to raise capital and demonstrated higher survival rates in comparison to their counterparts.

Despite these insights, there remains a need for comprehensive studies that examine the effectiveness of regulatory sandboxes across different jurisdictions, particularly in emerging markets. The present study aims to address this lacuna by analysing the role of regulatory sandboxes in promoting FinTech innovation and facilitating market entry in the United Kingdom, Singapore, and Hungary. Through detailed case studies, the objective is to understand how these frameworks operate in diverse regulatory environments and their impact on the FinTech sector.

2. Materials and Methods

2.1. Conceptual Foundations of Regulatory Sandboxes

The concept of regulatory sandboxes emerged in the mid-2010s as a response to the tension between financial innovation and regulatory certainty. The term refers to controlled environments established by financial regulators in which FinTech firms can test new products and services under relaxed regulatory conditions, but under close supervision (Kálmán, 2020; Miglionico, 2022). This model was first formally introduced by the UK's FCA in 2016, thus marking a significant paradigm shift in regulatory strategy from ex-post enforcement to ex-ante facilitation of innovation (Arner et al., 2017; Kálmán, 2020; Hellmann, Montag & Vulkan, 2022).

The regulatory sandbox is a concept designed to reduce the barriers to entry for start-ups and enable rapid experimentation without the full burden of compliance, which often represents a significant constraint for small, innovative firms (Zheng & Wu, 2024). Nevertheless, this approach has given rise to theoretical and practical debates. According to scholars such as Lemma (2020), sandboxes represent a component of a more extensive trend of responsive regulation, within which regulators transition from a rigid rule-based model to more dynamic and iterative frameworks. Consequently, sandboxes should be regarded not only as a testing mechanism, but also as an indication of a regulatory culture shift.

The extant literature identifies several key dimensions along which sandboxes vary (Liu et al., 2024). These include institutional design, eligibility criteria, regulatory relief offered, supervision intensity, and post-sandbox transition mechanisms. The diversity of approaches is exemplified in the comparative analysis of sandbox initiatives in the UK, Singapore, and Lithuania, each of which reflects different regulatory priorities and market conditions (Zetzsche et al., 2017; Raudla et al., 2024).

The Hungarian context has received comparatively less attention in global literature, although this situation is beginning to change. According to the Hungarian FinTech Strategy (2019), the National Bank of Hungary (MNB) views the establishment of sandboxes as a core pillar in promoting domestic FinTech growth and digital transformation, particularly in collaboration with incumbent financial institutions and international innovation hubs.

Notwithstanding the prevalence of sandboxes, critics have voiced concerns regarding the potential for regulatory capture and imbalanced competitive advantages. As posited by certain authors, the issue of 'selection bias' is a salient concern. This pertains to the notion that the ability to successfully navigate the sandbox application processes is exclusive to firms that possess both robust legal and technical capabilities. This phenomenon has the potential to perpetuate existing inequalities within the FinTech ecosystem (Arslanian & Fischer, 2019).

2.2. The Impact of Regulatory Sandboxes on Innovation and Market Entry

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A substantial body of empirical evidence has emerged that lends support to the proposition that regulatory sandboxes have the potential to substantially boost innovation in the FinTech sector and to facilitate market access for emerging firms. These environments offer regulatory relief in addition to credibility, visibility, and access to valuable mentorship and stakeholder networks.

A seminal study by Cornelli et al. (2024 and 2024a) analysed over 500 FinTech firms that participated in the UK's FCA sandbox, finding that these firms experienced a 15% higher likelihood of securing subsequent funding and exhibited greater survival rates compared to a matched control group. These outcomes suggest that participation in sandboxes may serve as a quality signal to investors and consumers alike.

In a similar vein, a comparative report by the World Bank observed that well-designed sandbox regimes have the potential to facilitate the identification of regulatory gaps during the early stages of the product development cycle, thereby reducing the time required to market a product and enhancing long-term compliance alignment (World Bank, 2020). This is of particular importance in regulatory systems that are still in the process of development, such as in Hungary, where the sandbox model is employed to reduce systemic entry barriers.

Aside from capital access, innovation speed has been documented as another advantage. It has been reported that startups within sandbox environments experience accelerated product development cycles, attributable to streamlined communication with regulators and adaptive compliance processes (Lui & Ryder, 2021). This finding is consistent with theoretical models of "innovation-through-experimentation", in which reduced regulatory friction catalyses iterative product refinement (Rainey, 2021).

However, it should be noted that not all impacts are unequivocally positive. It has been demonstrated by certain studies that there are issues with regard to the accessibility of sandboxes, particularly for micro-enterprises or firms located outside of capital-intensive urban hubs. Additionally, there is an ongoing debate regarding whether sandbox-tested firms gain an unfair market advantage through "soft approval," which could potentially distort market dynamics (Kapsis, 2021; Raudla, 2025).

Notwithstanding the aforementioned limitations, the extant body of evidence suggests that regulatory sandboxes play a facilitative – if not transformative – role in supporting FinTech ecosystems. Nevertheless, the success of the aforementioned parties is contingent upon the transparency of the admission process, the clarity of the regulatory relief provided, and the mechanisms for post-sandbox integration into the mainstream financial system.

2.3. Methodology

The present study employs a qualitative, document-based research methodology in order to investigate the role of regulatory sandboxes in supporting FinTech innovation and facilitating market entry. The present study employs a multiple-case study design, focusing on three jurisdictions: the UK, Singapore, and Hungary. The selection of these countries was based on the following criteria: their diverse regulatory maturity levels, sandbox models, and relevance to the broader FinTech policy discourse.

The research is entirely dependent on secondary data sources, including official publications from financial regulatory authorities (e.g., the UK FCA, the Monetary Authority of Singapore, and the MNB), academic journal articles, policy reports, and industry analyses. The key documents utilised in this study encompass national FinTech strategies, annual reports of sandbox programs, academic monographs, and case studies published by FinTech industry associations.

The content of these documents was subjected to qualitative content analysis, with the aim of identifying recurring themes, regulatory patterns, and innovation-related outcomes across the selected jurisdictions. The coding was conducted manually, with emphasis placed on three key analytical dimensions: the institutional design of the sandbox, the regulatory benefits provided to participants, and observable outcomes related to innovation performance and market access.

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In the absence of primary data, the findings are interpreted through the lens of theoretical triangulation, comparing insights from multiple academic and policy-oriented frameworks. Whilst this approach ensures analytical depth, it is acknowledged that the absence of direct stakeholder perspectives – such as those from sandbox participants or regulators – constitutes a limitation. Nonetheless, the substantiality and scope of extant secondary literature provides a robust foundation upon which cogent conclusions regarding the impact and efficacy of regulatory frameworks may be formulated.

3. Results

3.1. The UK – FCA Regulatory Sandbox

The UK is widely recognized as the birthplace of the modern regulatory sandbox. Launched in 2016 by the FCA, the UK's sandbox has served as a model for numerous other jurisdictions and is often cited in the academic and policy literature as a benchmark for best practices in regulatory innovation.

The FCA sandbox was introduced as part of Project Innovate, a broader initiative aimed at supporting innovation in financial services while ensuring consumer protection and market integrity. The sandbox offers a controlled environment where eligible FinTech firms can test innovative products, services, or business models with real customers, subject to appropriate safeguards.

The regulatory sandbox program implemented by the FCA is structured around five core objectives, each designed to balance innovation with regulatory oversight. First, the sandbox seeks to encourage competition and innovation within the financial services sector by enabling new entrants and unconventional business models to test their ideas without facing immediate full regulatory burdens. Second, it aims to reduce the time and cost associated with bringing innovative ideas to market, recognizing that early-stage FinTech firms often face significant compliance hurdles that can stifle creativity and market entry.

Third, the program places a strong emphasis on identifying appropriate consumer protection safeguards during the testing phase. By doing so, it ensures that experimental products and services are assessed for potential risks to consumers, thus maintaining public trust in the financial system. Fourth, the sandbox initiative strives to improve the regulator’s understanding of emerging technologies. Through direct engagement with innovative firms, the FCA can better anticipate technological trends and adapt its regulatory frameworks accordingly. Finally, the sandbox is designed to inform regulatory policy and facilitate better rule-making. Insights gained from sandbox operations provide valuable empirical evidence that supports the development of more nuanced, flexible, and forward-looking financial regulations.

Together, these objectives demonstrate the FCA’s proactive approach to regulating innovation. Rather than applying rigid traditional frameworks to nascent technologies, the sandbox model exemplifies a more collaborative, adaptive form of financial supervision, which has since been emulated by numerous jurisdictions worldwide (Washington et al., 2022).

The FCA’s regulatory sandbox operates on a cohort-based model, with periodic application windows allowing firms to submit proposals for participation. Each cohort is structured to ensure that a manageable number of firms can be admitted and supervised effectively, thereby maintaining the integrity and quality of the testing environment. Firms selected for the sandbox receive a tailored set of regulatory tools, specifically designed to address the particular regulatory challenges associated with their innovations.

These tools include, but are not limited to, restricted authorizations, which permit firms to operate within a limited scope without requiring full licensing; individualized regulatory guidance, where the FCA provides bespoke advice on how regulatory obligations apply to the novel service or product; and waivers or modifications of specific FCA rules, where such deviations are legally permissible. Additionally, participants benefit from direct access to FCA supervisory teams, facilitating continuous dialogue and real-time regulatory support throughout the testing phase.

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Since its inception, the FCA sandbox has supported almost 200 firms across seven distinct cohorts and an always open sandbox, covering a wide range of FinTech activities such as digital payments, blockchain solutions, regtech applications, and robo-advisory services. To gain admission, applicants must meet stringent eligibility criteria, demonstrating that their innovations are genuinely novel, that they provide clear benefits to consumers, and that sandbox participation is necessary due to prevailing regulatory uncertainty or other compliance-related barriers. This selective admission process ensures that the sandbox remains focused on initiatives with the highest potential for positive market impact and consumer welfare enhancement.

The structured design and rigorous selection mechanisms of the FCA sandbox have contributed to its reputation as a leading model for innovation-friendly regulation. However, while the sandbox has demonstrated significant success in facilitating FinTech experimentation and market entry, it also presents complex challenges that warrant critical examination. Key questions remain regarding the extent to which sandbox participation translates into long-term firm success, the risk of regulatory favoritism, and the potential for broader systemic impacts on competition and financial stability. The following sections explore the empirical outcomes observed among sandbox participants and assess the strengths and limitations of the FCA's approach within a comparative international framework.

Empirical evidence increasingly supports the view that participation in the FCA's regulatory sandbox generates significant positive outcomes for FinTech firms. A comprehensive study conducted by Cornelli et al. (2024) demonstrated that firms admitted to the sandbox exhibited approximately a 15% higher likelihood of securing external funding compared to their non-participating counterparts. Furthermore, these firms also showed enhanced survival rates and accelerated product development trajectories, suggesting that sandbox participation can serve as a quality signal for both investors and consumers.

Beyond firm-level benefits, the sandbox has also contributed substantively to regulatory learning and institutional adaptation. Insights derived from sandbox experiments have directly informed several important regulatory updates, including refinements to guidelines on digital identity verification, the development of open banking APIs, and the emerging classification standards for crypto-assets. This iterative feedback mechanism between regulators and innovators has not only improved the responsiveness of the UK's financial regulatory framework but has also reinforced the country's positioning as a leading global FinTech hub.

Nevertheless, the sandbox model is not without criticism. Scholars have identified potential concerns regarding accessibility biases, noting that firms with greater legal and technical resources may have disproportionate success in navigating the sandbox application and testing processes. Moreover, there is an ongoing debate about the risk of regulatory capture, whereby sandbox initiatives could become overly influenced by incumbent interests or dominant market players, potentially distorting competition and undermining the sandbox's foundational objective of promoting inclusive innovation (Zetzsche et al., 2017).

While the FCA sandbox has thus proven effective in fostering FinTech innovation and regulatory modernization, a broader comparative analysis with other leading sandbox models, such as those implemented in Singapore and Hungary, is necessary to fully understand the diverse design choices, contextual adaptations, and systemic impacts that characterize the global regulatory sandbox landscape.

3.2. Singapore – MAS FinTech Regulatory Sandbox

Building on the insights gained from the UK's pioneering sandbox model, it is instructive to examine how other jurisdictions have adapted the regulatory sandbox concept to their specific market environments and strategic objectives. Singapore has emerged as one of the most proactive and innovation-driven jurisdictions in the global FinTech landscape (Pei, 2018). Recognizing the transformative potential of financial technologies, the Monetary Authority of Singapore (MAS) launched its FinTech Regulatory Sandbox in 2016, shortly after the establishment of the UK's FCA sandbox. This initiative formed part of a broader strategic vision to position Singapore as a leading

FinTech hub not only within Asia but also on the global stage. (Chia Der Jiun, 2024) The MAS sandbox represents a distinctive regulatory approach characterized by operational agility, strong alignment with national innovation strategies, and an emphasis on cross-border scalability. In the following section, the structure, operation, and observed impacts of Singapore's sandbox framework are analyzed, providing valuable comparative perspectives on the role of regulatory experimentation in fostering FinTech innovation.

The MAS regulatory sandbox operates within a highly centralized and coordinated regulatory framework, reflecting Singapore's technocratic governance model and its strategic commitment to innovation-led economic growth. In contrast to the UK's cohort-based approach, the MAS initially adopted a rolling admissions model, whereby applications for sandbox participation are accepted throughout the year. This continuous intake structure significantly enhances flexibility and accessibility for FinTech firms, allowing them to align their innovation cycles with regulatory engagement in a more dynamic manner (MAS, 2024).

Recognizing the need to further streamline regulatory experimentation, the MAS introduced the Sandbox Express in 2020, a fast-track mechanism designed for low-risk FinTech innovations. Under this model, eligible firms – such as those involved in insurance brokering, remittance services, and business-to-business (B2B) lending – can obtain approval to commence live testing within as little as 21 days, provided that they meet a set of predefined, standardized conditions. This expedited pathway reflects Singapore's broader policy emphasis on regulatory efficiency without compromising financial stability or consumer protection. In 2022, the MAS introduced the Sandbox Plus initiative as an enhancement of its existing regulatory sandbox framework. Designed to support a broader spectrum of FinTech innovations, including higher-risk and more complex projects, Sandbox Plus offers extended testing periods, financial grants to offset development and regulatory costs, and a streamlined transition pathway toward full licensing. This expanded model reflects Singapore's strategic commitment to fostering an inclusive and dynamic FinTech ecosystem capable of scaling innovations from experimental stages to market maturity (Chen, 2020).

Moreover, the MAS sandbox is not an isolated initiative but is embedded within a comprehensive suite of national innovation strategies. These include the Smart Financial Centre strategy, which envisions Singapore as a global leader in digital finance; Project Ubin, a groundbreaking blockchain-based interbank payment initiative; and an array of grants and acceleration programs offered through the Singapore FinTech Festival, the largest FinTech event of its kind globally. This integrated approach ensures that regulatory experimentation is closely tied to wider efforts at ecosystem development, talent cultivation, and international collaboration.

The MAS sandbox provides participating firms with several key forms of regulatory support, carefully calibrated to facilitate innovation while safeguarding financial stability and consumer interests. Among the primary mechanisms offered are the relaxation of licensing requirements, allowing firms to conduct limited live testing without undergoing the full licensing process; tailored reporting obligations, which reduce compliance burdens while maintaining appropriate oversight; and structured engagement with MAS supervisory officers, fostering an environment of collaborative regulatory dialogue.

Applicants seeking entry into the sandbox must satisfy a set of clearly articulated eligibility criteria. First, the proposed financial service must be demonstrably innovative, offering novel functionalities or addressing previously unmet market needs. Second, the applicant must show that sandbox participation is necessary due to existing regulatory constraints that would otherwise inhibit or delay market entry. Third, firms must be capable of implementing appropriate safeguards to manage any risks posed to consumers or the financial system during the live testing phase.

Between 2016 and 2022, the MAS sandbox received more than 70 applications, of which over 40 projects were accepted for live testing. These projects spanned a diverse array of FinTech sectors, including robo-advisory services, digital insurance solutions, and blockchain-based payment systems, reflecting the sandbox's broad technological scope and its role as a catalyst for a wide range of financial innovations.

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The robust design and carefully structured participation criteria of the MAS sandbox have played a pivotal role in shaping its operational success and attractiveness to a broad spectrum of FinTech innovators. However, beyond the procedural architecture, it is essential to evaluate the tangible impacts of the sandbox on market dynamics, firm performance, and regulatory development. The following section examines the empirical outcomes associated with Singapore's sandbox initiative, highlighting its contributions to FinTech sector growth, regulatory evolution, and cross-border financial innovation.

Empirical observations indicate that Singapore's regulatory sandbox has had tangible impacts on the growth and diversification of the FinTech sector, particularly by facilitating cross-border experimentation and international collaboration. Several firms leveraging the MAS sandbox have successfully tested innovative solutions that were subsequently exported to broader regional markets, notably in Southeast Asia and the Middle East, including Malaysia and the United Arab Emirates. This ability to act as a launchpad for international expansion underscores the sandbox's strategic role in promoting Singapore as a FinTech gateway for the region.

A key strength of the MAS sandbox model lies in its emphasis on regulatory clarity and scalability. Firms graduating from the sandbox are provided with clear, structured guidance on the requirements for obtaining full regulatory authorization, thereby smoothing the transition from experimental to mainstream operations. Additionally, the continuous feedback loop established between sandbox participants and regulatory authorities has contributed significantly to policy evolution, informing substantive updates to legislation such as the Payment Services Act (PSA) and the regulatory frameworks for digital banking licenses.

Nonetheless, critical perspectives have emerged regarding certain unintended consequences of the MAS approach. Scholars have noted the risk of "innovation lock-in," whereby firms may overly tailor their solutions to fit sandbox-specific regulatory parameters, potentially limiting their adaptability in broader or less supportive market contexts. Furthermore, the MAS's strategic focus on scalability and regional outreach may, at times, come at the expense of fostering domestically-oriented, inclusion-driven innovations, particularly those targeting underserved local populations (Arslanian & Fischer, 2019).

While Singapore's sandbox demonstrates how regulatory experimentation can be strategically leveraged to drive international FinTech expansion and policy innovation, it is equally important to explore how emerging markets, such as Hungary, have adapted the sandbox model to their unique regulatory, economic, and technological contexts.

3.3. Hungary – MNB FinTech Regulatory Sandbox

Hungary represents a rapidly evolving FinTech ecosystem within the European Union, characterized by a growing institutional focus on digital transformation and innovation-driven regulatory reform. In line with broader national and EU-level strategic objectives, the MNB launched its regulatory sandbox initiative in 2018 as a central component of its FinTech strategy. The sandbox forms part of a comprehensive agenda aimed at enhancing financial innovation, promoting financial inclusion, and adapting the regulatory framework to accommodate the opportunities and challenges presented by emerging technologies. In the following section, the structural design, operational mechanisms, and observed impacts of Hungary's sandbox are examined, shedding light on the particular dynamics of regulatory experimentation in an emerging market context (Fáykiss et al., 2018).

The Hungarian regulatory sandbox operates in alignment with the Hungarian FinTech Strategy (2019–2022) and the more recent MNB FinTech and Digitalisation Report (2024), both of which emphasize the creation of a safe, innovation-conducive regulatory environment. Central to the MNB's approach is the objective of ensuring that digital transformation enhances the competitiveness, efficiency, and resilience of the domestic financial system, while maintaining a strong commitment to consumer protection and financial stability.

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Distinct from cohort-based models employed in jurisdictions such as the UK, the Hungarian sandbox follows a continuous, case-by-case admission framework. Under this model, applications are evaluated individually, allowing for greater flexibility and responsiveness to the specific needs of market participants. The sandbox is open to a wide range of financial market actors seeking to introduce innovative products, services, or business models that necessitate a temporary, supervised regulatory environment in order to test feasibility, compliance, and risk management practices before proceeding to full market deployment.

The Hungarian regulatory sandbox offers a set of carefully designed tools aimed at facilitating safe and effective financial innovation within a supervised framework. Among its core features is the provision of temporary exemptions or simplifications from certain licensing obligations, enabling firms to conduct limited-scope testing without the need for full regulatory authorization. Participants also benefit from tailored regulatory guidance during the testing period, which allows for a more nuanced and iterative approach to compliance challenges associated with novel financial products or services.

In addition, the sandbox mandates structured consumer protection and data governance requirements, ensuring that innovations are tested within a framework that prioritizes the rights and security of consumers. A notable aspect of the Hungarian model is its explicit emphasis on alignment with European Union regulations, including the Payment Services Directive 2 (PSD2), Markets in Financial Instruments Directive II (MiFID II), Anti-Money Laundering Directives (AMLD), and, more recently, the Markets in Crypto-Assets Regulation (MiCA) applicable to digital assets and crypto-innovations.

Importantly, the sandbox is integrated into the broader institutional structure of the MNB Innovation Hub, which supports a wide range of initiatives aimed at promoting financial literacy, cybersecurity resilience, and digital identity verification standards. As such, the Hungarian sandbox is not merely a regulatory waiver mechanism but operates as a supervisory dialogue platform, fostering continuous engagement between innovators and regulators to better anticipate and manage the risks associated with financial technological advancement.

The comprehensive design and strategic integration of the Hungarian sandbox within the broader innovation ecosystem underscore its potential as a catalyst for domestic FinTech development. However, in order to fully assess its effectiveness, it is necessary to examine the observable impacts of the sandbox on firm behavior, market dynamics, and regulatory evolution. The following section analyzes the empirical outcomes associated with the MNB sandbox initiative, offering insights into its achievements, challenges, and broader implications for financial innovation in emerging EU markets.

Recent analyses, including findings from the HUNFINTECH 20/20 report and the MNB FinTech and Digitalisation Report (2024), indicate that Hungary's FinTech ecosystem has undergone significant expansion in recent years. Currently, the sector encompasses over 200 registered firms, with a predominance of business-to-business (B2B) focused micro and small enterprises. These firms exhibit strong technological orientation, particularly toward data analytics, blockchain solutions, and digital payment innovations, reflecting broader global trends in FinTech specialization.

Although comprehensive quantitative evaluations of the sandbox's long-term impacts remain limited, qualitative evidence suggests that firms participating in the regulatory sandbox experience greater regulatory clarity and accelerated market adaptation compared to their non-participating peers. Nevertheless, several structural barriers persist. Bureaucratic complexity within the application and supervision processes, along with limited public visibility of the sandbox program, continue to constrain its broader uptake among emerging FinTech actors.

Moreover, despite promising technological capabilities, the export activity of Hungarian FinTech firms remains moderate. According to recent microdata-based research, higher added value, larger firm size, and foreign ownership are positively correlated with an increased likelihood of export engagement. These findings suggest that while the sandbox has successfully lowered certain

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entry barriers, further policy support may be necessary to facilitate international scaling and to enhance the global competitiveness of the domestic FinTech sector.

The Hungarian regulatory sandbox initiative serves as a catalyst for fostering structured regulatory experimentation and enhancing the dialogue between FinTech innovators and supervisory authorities (Kerényi & Molnár, 2017). By facilitating early-stage regulatory engagement and lowering compliance-related entry barriers, the sandbox contributes to the development of a more dynamic and innovation-friendly financial ecosystem. However, its long-term effectiveness is contingent upon the resolution of several structural and operational challenges.

First, the relatively limited public visibility and outreach of the sandbox restrict its accessibility, particularly for smaller and less well-connected FinTech startups. Expanding awareness initiatives and simplifying application procedures could substantially enhance the inclusiveness and diversity of sandbox participants. Second, bureaucratic complexity within the testing framework may deter some innovators, suggesting the need for more streamlined supervisory processes and adaptive regulatory support during the testing phase.

Third, in order to maximize its systemic impact, the sandbox must be more fully integrated into Hungary's broader FinTech and digital finance strategy. This includes closer alignment with initiatives supporting venture financing, tax incentives for innovative firms, and infrastructure development, particularly in areas such as cybersecurity and digital identification. Strengthening these complementarities would enable sandbox-tested firms to scale more effectively both domestically and internationally.

Finally, the Hungarian sandbox must navigate the ongoing evolution of the European regulatory landscape, particularly in light of the Markets in Crypto-Assets Regulation (MiCA) and the Digital Operational Resilience Act (DORA). Ensuring that sandbox activities remain consistent with emerging EU requirements will be critical for maintaining regulatory coherence and facilitating cross-border scalability.

In sum, while Hungary's regulatory sandbox has established a valuable foundation for innovation-friendly financial supervision, targeted policy enhancements and structural reforms are necessary to fully unlock its potential as a driver of sustainable FinTech growth.

4. Discussion

The comparative analysis of regulatory sandbox frameworks in the UK, Singapore, and Hungary reveals a shared strategic ambition to promote FinTech innovation through supervised regulatory experimentation. Despite this common objective, the design, implementation strategies, and observed impacts of the sandbox models differ considerably across jurisdictions, reflecting variations in institutional maturity, regulatory philosophies, and market dynamics.

The United Kingdom's FCA sandbox emerges as the most institutionalized and influential model, distinguished by its structured cohort system, strong signaling effects to investors, and a well-established feedback mechanism that informs regulatory policymaking. The UK experience illustrates how regulatory clarity combined with reputational support can significantly lower barriers to innovation and facilitate early-stage investment in FinTech enterprises.

In contrast, the Monetary Authority of Singapore's (MAS) sandbox, particularly with its Sandbox Express variant, excels in operational agility and regional scalability. Its emphasis on fast-track regulatory approvals, robust public-private collaboration, and strong alignment with national digitalization and innovation goals underscores the critical role of regulatory efficiency in supporting FinTech development in rapidly evolving and highly competitive markets.

Meanwhile, Hungary's regulatory sandbox, although younger and more limited in scope, plays a pivotal role in building trust and fostering dialogue between FinTech innovators and regulatory authorities. The Hungarian model demonstrates the adaptive potential of sandboxes in emerging European Union markets, although further efforts are needed to enhance accessibility, increase transparency, and strengthen post-sandbox integration mechanisms to fully realize its developmental impact.

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The comparative evaluation of regulatory sandbox initiatives across the UK, Singapore, and Hungary highlights several core contributions that these frameworks make to the development of FinTech ecosystems. First, regulatory sandboxes significantly contribute to enhancing regulatory clarity for emerging financial services, offering innovators a clearer understanding of compliance expectations and facilitating more predictable market entry pathways. Second, sandbox participation is associated with a faster time-to-market and supports iterative product testing, enabling firms to refine their offerings in close collaboration with regulatory authorities.

Third, empirical evidence suggests that sandbox initiatives improve access to funding, particularly for early-stage startups that benefit from the reputational advantages and investor signaling effects associated with regulatory endorsement. Fourth, sandboxes foster increased dialogue between innovators and regulators, promoting mutual understanding and enabling regulators to better anticipate and respond to technological developments.

Despite these positive outcomes, several challenges persist across jurisdictions. Ensuring fair access for micro-enterprises and marginalized innovators remains a critical concern, as resource-intensive application processes may inadvertently privilege larger or better-connected firms. Additionally, there is a risk of "sandbox capture", whereby dominant incumbents leverage sandbox participation to entrench market positions, potentially distorting competition. Furthermore, maintaining alignment with evolving European regulatory frameworks, such as the Markets in Crypto-Assets Regulation (MiCA) and the Digital Operational Resilience Act (DORA), poses an ongoing challenge for EU member states. Finally, a broader methodological issue concerns the need for systematic measurement of long-term sandbox impacts, extending beyond immediate firm-level outcomes to encompass sector-wide innovation dynamics and consumer welfare considerations.

Based on the comparative analysis of the regulatory sandbox initiatives in the UK, Singapore, and Hungary, several policy recommendations can be formulated to optimize the effectiveness of sandbox frameworks in fostering financial innovation while maintaining regulatory integrity.

First, there is a critical need to institutionalize systematic monitoring and evaluation mechanisms within sandbox programs. Establishing clear metrics – such as innovation success rates, post-sandbox funding trajectories, and consumer protection outcomes – would provide empirical foundations for assessing the sandbox's long-term efficacy and for refining regulatory approaches accordingly.

Second, policymakers should seek to foster international cooperation and interoperability among sandbox initiatives. Cross-border sandbox collaborations, mutual recognition schemes, and the alignment of regulatory standards, particularly within the context of the EU's Digital Finance Strategy, would enhance scalability opportunities for FinTech firms and facilitate seamless international expansion.

Third, enhancing accessibility and outreach must be prioritized to ensure that regulatory sandboxes do not disproportionately favor well-resourced entities. Simplifying application procedures, providing regulatory coaching, and actively engaging underrepresented innovators – including micro-enterprises and startups from less developed regions – would contribute to a more inclusive innovation ecosystem.

Fourth, it is essential to develop structured post-sandbox support mechanisms. Clear transition pathways from experimental testing phases to full market authorization would not only sustain innovation momentum but also reinforce compliance standards and consumer protection as firms scale their operations.

Finally, integrating insights generated through sandbox experimentation into broader legislative and regulatory processes would enable more adaptive, evidence-based rulemaking. Leveraging sandbox learnings systematically could ensure that financial regulation remains responsive to technological evolution, balancing the twin imperatives of fostering innovation and safeguarding market integrity.

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5. Conclusions

As the financial services sector continues to undergo rapid technological transformation, regulatory sandboxes are likely to remain pivotal instruments for balancing the dual objectives of fostering innovation and safeguarding financial stability. The comparative analysis of sandbox frameworks in the United Kingdom, Singapore, and Hungary underscores that while no universally applicable model exists, the careful calibration of sandbox design, operational processes, and integration with broader policy initiatives can substantially influence their success.

Effective sandboxes are characterized not only by their capacity to enable safe experimentation but also by their ability to inform adaptive regulatory practices, build trust among market participants, and promote competitive, consumer-oriented financial ecosystems. As regulatory landscapes evolve – particularly within the European Union's digital finance agenda – the role of sandboxes as dynamic, evidence-generating platforms will become even more critical.

In light of these developments, policymakers, regulators, and industry stakeholders must remain committed to iterative learning, international collaboration, and the continuous refinement of sandbox mechanisms to ensure that financial innovation serves the broader public interest in an increasingly digital and interconnected global economy.

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

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