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SUSTAINABLE ENTREPRENEURSHIP AND DIGITAL LEGITIMACY IN EUROPEAN UNION

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Received 18 October 2025; accepted 15 February 2026; published 30 March 2026

Abstract. The construction of the European Union's "digital single market" faces a paradox: improved availability of digital public services and infrastructure coexists with lagging uptake of mandatory digital administrative and compliance procedures by small and medium-sized enterprises (SMEs). Based on the European Interoperability Framework (EIF), this article reconstructs interoperability across different national legal jurisdictions and administrative systems as a market access condition and advocates for the proposal of "Institutional Middleware" as an interpretive mechanism to reveal how digital legality generates operational barriers and process inefficiencies at the legal/organisational level. Methodologically, this article adopts multi-source evidence design: firstly, we build the "Adoption Gap" index to quantify the gap between government service availability and enterprise usage rates; secondly, we combine e-government obstacle data and enterprise digital intensity index to identify the disproportionate compliance burdens on SMEs; finally, we verify the implementation efficiency of institutional tools through the hierarchical mapping of funds, standards and procurement rules and urban cases. The study found that the fixed cost of adapting internal workflows to external regulatory standards constitutes a hidden barrier for SMEs. The contribution of this article is to advance the perspective of institutional Middleware and to demonstrate how the EU can encapsulate compliance complexity into a reusable public infrastructure through policy combination, thereby providing large-scale institutional conditions for a sustainable entrepreneurial ecology.

Keywords: digital single market; European Interoperability Framework (EIF); innovation management; SMEs; sustainable entrepreneurship; Minimum Interoperability Mechanisms (MIMs)

Reference to this paper should be made as follows: Zhou, W., Krivins, A., Kaze, V. 2026. Sustainable entrepreneurship and digital legitimacy in European Union. *Entrepreneurship and Sustainability Issues*, 13(3), 388-404. <http://doi.org/10.9770/r4884369628>

JEL Classifications: L26; O33; H83; O38

1. Introduction

1.1 Background and Objectives

In this article, the authors use the following terminology. *Compliance and process adaptation* refers to the resources required to adapt internal business workflows to meet external regulatory standards (e.g., implementing specific data governance or e-ID software). *Digital legitimacy* is the institutionally determined ability of digital technologies to be recognised as legitimate, trustworthy, and acceptable through consistent compliance with regulatory, normative, and cognitive expectations. *Improved capacity*: the article refers to the EU's investment in digital infrastructure and the availability of digital public services (e.g., e-government portals and digital identity systems). *Interoperability as a market access condition* - in the context of the EIF, the article defines interoperability not just technically, but multidimensionally. It refers to the ability to interact across borders (between different EU Member States' jurisdictions) and across sectors (between public administration systems and private enterprises' business processes), encompassing legal, organisational, semantic, and

technical layers. The article discusses interoperability between different national legal jurisdictions (Member States) and between public administration systems and private enterprise workflows. *Lagging adoption* does not refer to optional market tools, but to the mandatory digital procedures required by EU regulations (e.g., the Digital Decade targets, Corporate Sustainability Reporting Directive CSRD, e-invoicing, and public procurement). SMEs are legally required to adopt these digital workflows to interact with public administrations, yet they face significant barriers leading to low uptake or abandonment. *Socio-technical frictions* refer to the operational blockages that occur when technical systems work but legal/organisational processes fail (e.g., a digital form exists, but the e-signature isn't recognised across borders). *Supply and demand divergence* is the gap between the "supply" of government digital services (measured by the Digital Public Service Index) and the "demand/usage" by firms and individuals (measured by Online Interaction rates). *Regressive constraints of friction* here means that the burden falls disproportionately heavier on smaller firms. Compliance costs are "fixed costs" that large firms can amortise, but which act as a high barrier for SMEs.

Over the past two decades, the European Union has promoted the "Digital Single Market" (DSM) through legislative integration and public investment, aiming to build a unified market that can compete with the United States and China. Its policy has long been based on linear logic: as long as digital infrastructure and interoperability improve, service adoption and enterprise innovation will follow. However, macro data reveals the "digital paradox" that improved supply-side capacity coexists with lagging demand-side adoption. This divergence shows that the key to restricting the European digital economy lies not in technological limitations but in socio-technical frictions (STFs). This friction stems from the conflict between legal responsibility and the operation of the technical system within the organisational process, which invisibly increases transaction costs and poses hidden barriers to small and medium-sized enterprises.

Based on this, the article proposes that the digital governance of the European Union is an institutional endeavour aimed at decreasing access barriers. In response to the regressive impacts of compliance on small and medium-sized enterprises (SMEs) during sustainable transformation, the EU is implementing an "Institutional Middleware" architecture. This architecture includes minimum interoperability mechanisms (MIMs), standardised procurement, and targeted funds such as the "Digital Europe Plan," to encapsulate the underlying legal and administrative complexities into a reusable infrastructure and offer a "plug-and-play" compliance environment for green entrepreneurship. This article discusses the Adoption Gap index. As shown in Figure 1, the EU Digital Public Service Index rose steadily (100 to 144.18) from 2017 to 2022, but the "Online Interaction" index fell back to 103.81 in 2022 after a temporary increase driven by the COVID-19 pandemic. This deviation confirms that the crisis-driven forced digitisation has not been transformed into endogenous power, and the interaction mode quickly retreats after the physical restrictions are lifted. The current state of digital services can be characterized as "available but not superior".

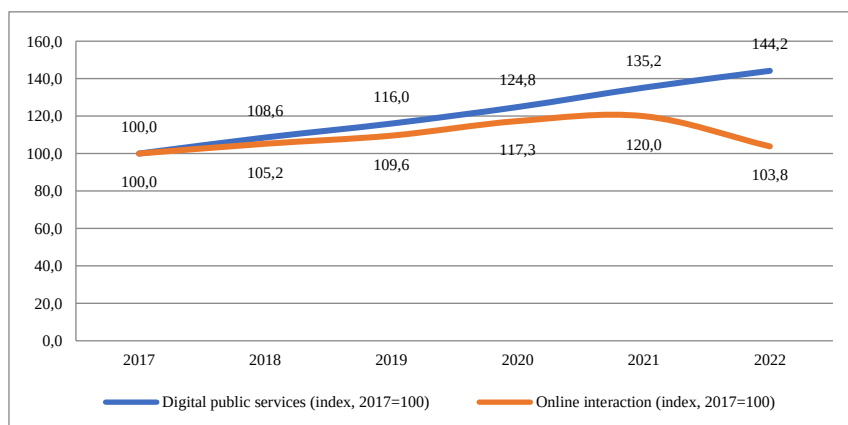


Figure 1. Adoption Gap in Digital Public Services (2017–2022)

Source: Compiled by authors based on Eurostat (2024a) and European Commission (2024a)

When digitisation fails to reduce process uncertainty and accountability ambiguity, administrative friction can offset technical advantages. For instance, if the complex signing process of transnational electronic tenders cannot achieve deep interoperability, the mere addition of API and computing power is insufficient to bridge the Adoption Gap (European Investment Bank, 2023).

Within the context of the European Green Deal and Corporate Sustainability Reporting Directive (CSRD), this issue becomes especially urgent. The new disclosure requirements impose a fixed cost that is hard for SMEs to bear. Without an affordable, automated compliance solution, environmental standards will burden the most innovative green small- and medium-sized enterprises. Therefore, interoperability is not only a technical feature but also a matter of economic justice, ensuring that SMEs share in the benefits of the green transformation (Godlovitch & Bodin, 2022).

The authors formulate three core research questions (RQs):

RQ1 (Diagnostic): Why has the "rise in supply-side capacity" in the EU digital single market not been transformed into "demand-side adoption"? This article will combine the friction between Figure 1 and EIF levels to explain how legal and organisational blockages lead to an institutional reality of availability rather than superiority.

RQ2 (Distribution Effect): Why does friction become regressive and pose more substantial barriers to SMEs? This article will combine an analysis of funding overlap with how the same set of legal requirements becomes the operating costs of large enterprises, while also examining the survival pressure on SMEs.

RQ3 (Policy Tool): How does the EU encapsulate compliance complexity through Institutional Middleware?

This article will discuss how MIMs, procurement rules and capital flow work together to reduce the cost of cross-domain expansion and cultivate a sustainable entrepreneurship. The contributions of this article are: (1) theoretically reconstructing interoperability as a market access condition for sustainable entrepreneurship; (2) the mechanism puts forward Institutional Middleware to explain the large-scale path under the high legality constraints of the European Union; (3) In practice, it provides policy inspiration on procurement and standard design for transition economies. The subsequent chapters will present the conceptual framework, research design and evidence discussion in turn.

1.2 Literature Review

Contemporary literature increasingly points to the fact that the challenges of digitalisation do not stem from a lack of technology but from issues of legitimacy, power, and institutional embeddedness. At the macro-social level, Staab and Sorg (2025) conceptualise this shift as the emergence of a digital eco-technocracy, where digital and green technologies are used to stabilise society through adaptation but also to generate new legitimacy crises. Their "negative dialectic of technocracy" offers an essential backdrop for analysing the EU: attempts to depoliticise environmental and digital conflicts via techno-administrative solutions heighten legitimacy's reliance on procedures, standards, and expertise. Studies of digital governance also support this shift from political to procedural legitimacy. Ramjit (2025) demonstrates that digitalisation transforms administrative legitimacy by increasing demands for transparency, accountability, and participation, while also exposing risks of reproducing inequalities and power asymmetries. Similarly, Moss (2025) stresses that it is precisely the characteristics of "effective" digital regulation - expertise, flexibility, and adaptability - that widen the gap between regulators and democratic society, turning legitimacy into an issue of justification and explainability rather than mere formal compliance. Together, these studies advance a key thesis: digital legitimacy is an end-to-end institutional process, not merely a byproduct of technological adoption.

At the organisational and entrepreneurial level, the literature consistently demonstrates that legitimacy in the digital context requires proactive, resource-intensive strategies. Research on digital servitisation in manufacturing (Wang & Cui, 2025; Christiansen & Aas, 2024; Christiansen & Aas, 2025) demonstrates that the adoption of digital services is determined not so much by their technical value as by a firm's ability to secure appropriate forms of legitimacy - regulatory, normative, and cognitive - at different stages of development and commercialisation. Crucially, the type of legitimacy required varies over time, making compliance an ongoing process rather than a one-time barrier to entry. A similar logic emerges in research on digital entrepreneurship. Imiren et al. (2024) demonstrate that in contexts with limited institutional resources, entrepreneurs are forced

to build digital advocacy, curation, and networking capabilities independently to gain legitimacy. Digital legitimacy functions as a fixed cost, disproportionately affecting small and resource-constrained entities. Financial and economic research (Mehmeti et al., 2024) complements this picture. May (2025) and Sonnerfeldt (2025) show that digital transformation can enhance corporate legitimacy through donations, transparency, and improved information quality, but these effects are more pronounced for large or institutionally embedded companies. Jiang et al. (2024) confirm that digitalisation reduces the opportunistic behaviour of controlling shareholders by acting as a mechanism of external oversight and legitimation (Krivins, 2018). Still, its effectiveness depends on the quality of institutions and corporate governance (Durguti et al., 2024). Thus, at the micro level, digital legitimacy acts as a continuous burden rather than an automatic consequence of digitalisation.

A separate strand of literature examines digital platforms as bearers of structural and "extensional" power. Greene and Gilbert (2024) demonstrate that digital platforms shape new institutions through permission systems, necessitating a rethinking of the very nature of legitimacy. Gilbert, Schrage and Behnam (2024) emphasise that "gatekeeper" platforms face, above all, a crisis of moral legitimacy that cannot be resolved by either pure self-regulation or traditional state control. Empirical studies of platforms in developing and transition economies (Chen et al., 2022) show that legitimation strategies depend on the platforms' ability to reallocate resources, assume quasi-public functions, and integrate into regulatory trajectories. This reinforces the asymmetry: large platforms can "internalise" the costs of legitimacy, while SMEs and new entrants remain dependent on fragmented compliance requirements. A growing body of literature links digitalisation to environmental legitimacy. Ai et al. (2025) and Mai (2025) show that digital inclusive finance promotes environmental legitimacy through green investment and innovation, but this effect is uneven across firm sizes and regions. These results confirm that digital instruments can reduce environmental compliance costs, but only when institutional risk-sharing channels are in place. Work on corporate digital responsibility and AI (Yoganathan et al., 2025) demonstrates that clients tend to trust state-institutionalised forms of legitimacy (e.g., compliance with the EU AI Act) rather than pure self-regulation. This highlights the importance of institutional mediation between technology and trust. This finding is echoed by research on e-banking adoption in Latvia (Kaže et al., 2007), which demonstrates that trust in institutional frameworks - rather than innovation alone - was critical for consumer uptake in a knowledge-based economy. Their study reinforces the idea that institutional mediation plays a decisive role in enabling technological legitimacy, particularly when information asymmetries or cultural resistance exist.

While current research focuses heavily on system-level legitimacy and firm strategies, several studies stress the need to examine the human and behavioural dimensions underpinning digital adoption. In particular, Kaže et al. (2022) present an innovative image-based methodology for understanding individual value orientations that drive decision-making in digital and sustainability contexts. Their work shows how personal value systems, such as openness to change or preference for tradition, can influence the willingness to engage with digital tools, particularly in uncertain regulatory environments. This value-based insight is especially relevant in designing inclusive digital ecosystems that respect cultural and motivational diversity.

Empirical research further links social values to systemic behaviours, including informal economies and regulatory avoidance. A study of population participation in the grey economy demonstrates that value orientation strongly predicts whether individuals perceive state regulations as legitimate and thus choose to comply or evade them. These findings suggest that building legitimacy at scale must go beyond formal compliance and actively address the socio-cultural perceptions of rules, which are critical to the EU's digital legitimacy strategy.

In the same context, the enabling role of digital environments in fostering sustainable entrepreneurship (Sceulovs et al., 2011; Sobczak, 2025; Varzaru, 2024). They argue that e-environment tools not only increase transactional efficiency but also promote value alignment between digital initiatives and broader sustainability goals, especially when implemented in small-scale economies. Similarly, the importance of coordinated spatial governance, where digital innovation is interlinked with community-level sustainability goals, is emphasised in the research (Miszczak et al., 2024). It highlights that governance efficiency and perceived legitimacy are

interdependent: digital systems must not only work but also be accepted and trusted within local socio-political ecosystems.

Despite the wealth of empirical research, the literature primarily analyses the legitimization strategies of individual actors (firms, platforms, entrepreneurs) or critiques technocratic legitimization regimes at the macro level. Work on transdisciplinary implementation support (Carey et al., 2024) only hints at a shift toward tools that enable collective deliberation and structuring of technological legitimacy, but does not offer scalable institutional solutions. In this context, the question of how the costs of digital and environmental legitimacy can be institutionally aggregated, standardised, and reused, particularly for the benefit of SMEs, remains underdeveloped.

Against this background, this study proposes considering institutional Middleware (MIM) as the missing layer of analysis between macro-debates about digital technocracy and legitimacy and firms' micro-strategies for ensuring compliance. Unlike existing work, which focuses on actors (Duarte & Carvalho, 2024; Calzati & van Loenen, 2025), this article shows how the EU, through standards, procurement (Krivins & Vilks, 2013), and financial instruments, transforms ongoing legitimacy costs into collective, reusable institutional pathways. This allows us to rethink the “double transition” – not as the sum of digitalisation and greening, but as an opportunity to design interoperable, auditable, and scalable compliance structures.

1.3 Research Objectives and Framework

To understand why technology supply has not automatically translated into adoption, it is not sufficient to rely solely on technology acceptance models (such as TAM). This article adopts a Socio-Technical Systems perspective to examine e-government and UDT infrastructure as a composite system comprising legal norms, organisational processes, semantic definitions, and technical interfaces. From this viewpoint, the technical capability of “available” does not necessarily align with the institutional arrangement of “diffusible,” and the adoption gap often stems from a disconnect across system levels. The European Interoperability Framework (EIF) offers a fundamental model for analysing this disconnection, and this article further proposes Institutional Middleware as an interpretive mechanism to clarify how the European Union alleviates hierarchical friction through a combination of policy tools, transforming compliance complexity into a reusable market infrastructure.

Since its initial proposal in 2004, EIF has become the foundation for coordinating EU digital public services (European Commission, 2004). EIF breaks down interoperability into four interdependent levels: Legal, Organisational, Semantic, and Technical. Any imbalance at any level can hamper the end-to-end process and cause “interoperability friction” (European Commission, 2017b; Campmas et al., 2022). Among these, legal interoperability has the most rigid “hard constraint” nature: even within the framework of the General Data Protection Regulation (GDPR), if the legal effect of electronic identity or signatures cannot be recognised across domains, the legality of the transaction will be immediately contested (European Commission, n.d.-a). Organisational interoperability focuses on aligning business processes. Variations in approval sequences and responsibility attribution across jurisdictions force enterprises to develop multiple compliance strategies, significantly increasing hidden costs (European Commission, 2017a). Semantic interoperability requires a shared understanding of data. In green governance, if definitions like “carbon footprint” lack standardised criteria, enterprises must resort to costly manual processes to replace automated compliance (European Commission, n.d.-a). Conversely, while technological interoperability has progressed with the widespread adoption of open standards, evidence indicates that a single technological enhancement cannot replace the need for aligned, overarching systems, prompting member countries to continue promoting national frameworks to bridge the remaining gaps (Kalogirou et al., 2022).

Based on this, this paper proposes Institutional Middleware as a theoretical extension of EIF in governance practice. Middleware is often referred to as “software glue” in computer science. Its function is to shield the underlying complexity between the operating system and the application, and to provide unified authentication, messaging, data access, and other general services (Tanenbaum & van Steen, 2017). By analogy, the EU's diversified legal and administrative system constitutes the underlying “operating system”, while the large-scale deployment of SMEs' transnational business and green solutions is like an “application”.

In the absence of Middleware, entrepreneurs must bear the adaptation cost of system fragmentation alone. Institutional Middleware is not a single technical solution but a combination of policies and institutional arrangements. It aims to encapsulate the compliance complexity under strict legal constraints into reusable modules, thereby reducing social and technological frictions and improving the feasibility of cross-domain expansion. Specifically, it comprises three complementary components: the minimum interoperability mechanism (MIMs) as a "standard interface", providing a general specification for cross-city systems (Open & Agile Smart Cities, 2025); a coordinated procurement rule for "agreement", which prevents locking and lowers the entry barrier by embedding interoperability clauses (UN-Habitat, 2023); and a strategic fund for "fuel", offering subsidies for system migration through DEP and NGEU (European Commission, 2022). Therefore, the theoretical framework of this article redefines "interoperability" from a purely technical issue into a market entry prerequisite, emphasising that the key to digital transformation in the European Union is not merely to enhance technical capabilities, but to unlock growth potential for a sustainable entrepreneurial ecosystem by publicising, modularising, and scaling up compliance costs.

2. Methods

This article adopts an explanatory research design using multi-source evidence. It builds an evidence chain that includes diagnosing the macro-adoption gap, identifying micro-friction mechanisms, hierarchical mapping of policy tools, and application verification in urban cases, systematically answering RQ1-RQ3. The core judgement of the study is that the adoption of EU digital governance is not mainly due to insufficient technology supply but is closely related to STFs at the legal and organisational levels of EIF and its regressive burden on SMEs, and can be partially encapsulated and publicised through the tool combination of Institutional Middleware.

For RQ1 (diagnosis), this article first builds a time series index to depict the deviation between supply and adoption. We use the digital public service dimension in the European Commission's European Innovation Scoreboard 2024 to represent the supply side, and we extract Eurostat's statistical data on online interactions between individuals and public institutions to represent the demand side. To ensure vertical comparability, this study indexed the data on both sides ($Index_t = \frac{Value_t}{Value_{2017}} \times 100$) based on 2017. The two curves presented after visualisation intuitively established the empirical starting point of subsequent friction diagnosis.

To further identify the friction mechanism in RQ1 and analyse the distribution effect in RQ2, this paper integrates two types of complementary micro-evidence. First, Eurostat's "e-government barrier" dataset reveals the block structure of online interaction: statistical results show that, compared with pure technical failures, legal frictions such as identification and electronic signatures carry significant weight. To better understand the consequences of process fracture from an enterprise perspective, we introduced the eGovernment MONITOR 2024, released by the German Initiative D21. The microdata in the report characterises this barrier as *Medienbruch* (media discontinuity) and *Haftungsangst* (liability anxiety), and explain how risk-avoidance psychology leads users to retreat from digital channels to offline alternatives. In the enterprise heterogeneity analysis of RQ2, the research focuses on verifying the regressive nature of compliance costs. Through the measurement and analysis of Eurostat's "Digital Strength Index", SMEs and large enterprises show significant hierarchical differences in their digital capabilities. It is worth noting that the supplementary investigation evidence from the European Investment Bank (EIBIS 2025) excludes the competitive explanation of "infrastructure shortage" and clarifies that the current constraint bottleneck has been significantly transferred from the physical access layer to the application adaptation layer, thus confirming the asymmetric constraints of institutional friction on small and medium-sized enterprises.

For RQ3 (policy tools), this article breaks down the operation of institutional Middleware into three elements: capital, standards, and procurement rules. Based on the EU "large-scale pilot plan" budget document, we have rebuilt the middleware capital investment structure. At the same time, in combination with the NGEU/RRP data set from the Bruegel Research Institute, tagging analysis further highlights the overlap between digital investment and green and social goals. It verifies the guiding role of funding tools in shaping sustainable

application scenarios. In terms of standards and rules, this article maps design fragments, such as eIDAS (Electronic Identification, Authentication, and Trust Services) and GDPR, procurement interoperability terms, and intelligent data models, to the legal, organisational, semantic, and technical levels of the EIF according to the preset codebook.

Finally, this article selects Barcelona and Bologna as case studies for mechanism verification. The former exemplifies the middleware application mode driven by "procurement rules and data ownership clauses," and the latter illustrates the process remodelling mode driven by "participation process institutionalisation and LDT sandbox." Both cases are supported by official documents, project reports, and practical materials to demonstrate the real effectiveness of cross-level mechanisms in urban governance.

3. Results

3.1. Result A: The cost of legitimacy and the friction between social technology

In the highly regulated market environment of the European Union, the main obstacle to digital adoption is not primarily the lack of system availability, but rather the establishment and recognition of legitimacy in the digital space across different domains. The trust system in the physical world relies on paper documents, seals, face-to-face identity verification, and stable written norms. These mechanisms define clear boundaries for evidence, effectiveness, and responsibility in long-term institutional practice. Once in the digital environment, legitimacy is embedded in end-to-end processes such as identity verification, electronic signatures, data compliance, and audit trails, which are based on identity and signature validity under the framework of eIDAS, as well as the legitimacy and traceability of data processing under GDPR (Sharif et al., 2022). Consequently, legitimacy is no longer just a background condition but becomes a prerequisite for establishing transactions and initiating a series of standard operational processes. These frictions are mainly located within the legal and organisational layers of the EIF. They are exacerbated in high-frequency B2G and B2B2G interactions, especially during bidding, licensing, subsidy applications, and CSRD-mandated ESG reporting. This scenario is not simply a matter of "citizen experience". Still, it serves as a critical channel for entrepreneurial subjects to access the market, because the failure of identity and signature verification can directly prevent transactions from being established, thus creating barriers rather than minor inconveniences. Eurostat statistics on the problems encountered by Internet users when interacting with public authorities provide a direct observation of the pattern of friction (see Figure 2).

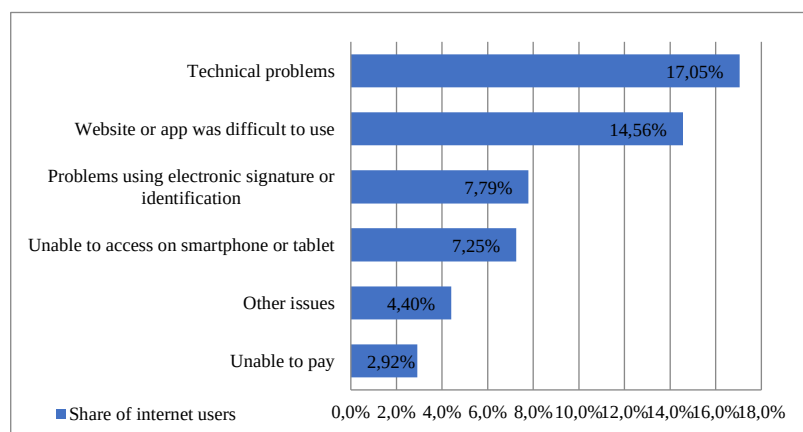


Figure 2. Types of Socio-Technical Frictions in E-Government Interactions.

Source: Eurostat (2024b).

In terms of proportion, "technical problems" account for the highest share (17.05%), making it easy to attribute adoption obstructions to system congestion or website failures. However, what is more explanatory is the type of friction associated with the nature of "hard constraint." Although the "electronic signature or identification problem," accounting for 7.79%, is not the highest, it addresses the core institutional conditions for digital transactions. In B2G scenarios, website failures usually result in delays, and enterprises may still submit

materials after the system is restored; however, failures in identity authentication or signature mean the system cannot recognise the subject's qualifications, preventing the submission of tenders, the application for licences, and the validation of contracts. This mechanism can be summarised as a chain of failures from "identity and signature failure" to "transaction non-establishment," resulting in market access failure due to the transaction being legally invalid, not merely a loss of efficiency. Consequently, this type of friction highlights a bottleneck in the EIF Legal Layer, rooted in the institutional inconsistency of recognising effectiveness and traceability of responsibility. It cannot be easily resolved through UI optimisation or server upgrades (Sharif et al., 2022). Simultaneously, when the legal layer's bottleneck and organisational layer's process are not aligned or superimposed, even if the service is technically "available," it is unlikely to be regarded as "better" by market participants. This results in a return to offline methods and a diminished trust in digital channels.

Germany's micro-evidence further shows how legal and organisational frictions can be turned into risk perception and abandonment behaviour (Figure 3).

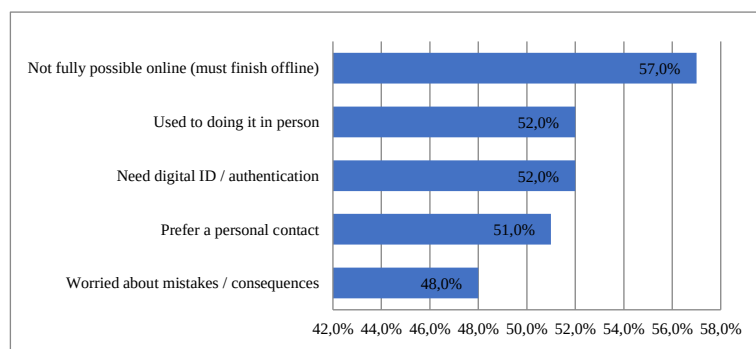


Figure 3. Reasons for Abandoning E-Government Services in Germany

Source: Initiative D21 (2024).

The survey shows that 57% of users give up because the process cannot be completed entirely online, indicating a gap in Organisational Interoperability, that is, *Medienbruch*. When the end-to-end process is split into online and offline sections, users need to understand two sets of rules and material requirements simultaneously. Digitalisation not only reduces transaction costs but also increases coordination costs and uncertainties. More importantly, 48% of users said that they were "afraid of making mistakes or facing consequences", which can be summarised as *Haftungsangst*. In Germany's legalised environment, *Schriftformerfordernis* (written-form requirement) has long been regarded as the cornerstone of legal certainty. The digital process is more likely to raise uncertainty about the validity of the signature, the integrity of the evidence, and the path to relief. Small and medium-sized enterprise owners are worried about the irreversible consequences of an incorrect submission or about the lack of the same psychological certainty in electronic materials in dispute scenarios. Given that software is within the scope of the EU Product Liability Directive, this uncertainty may also spill over into adoption decisions for digital products and services (Weiss, 2025). Therefore, *Haftungsangst* is not an individual preference but a rational response to the uncertainty surrounding legal effectiveness and organisational process fractures. It explains why "passive digitisation in crisis times" is challenging to transform into normal adoption.

The above friction does not affect enterprises of different sizes equally. The main reason is the fixed cost nature of compliance expenses. Establish a data governance and audit system that complies with GDPR, purchase and integrate qualified eIDAS-related services, and understand and implement cross-border procurement and authorisation rules, all of which require ongoing investment. Large enterprises can spread fixed costs and achieve reuse through specialised legal, compliance, and IT teams. In contrast, for small and medium-sized enterprises (SMEs) with limited resources, these exact requirements are more likely to act as market-entry barriers. The digital intensity index further highlights the difference between enterprises.

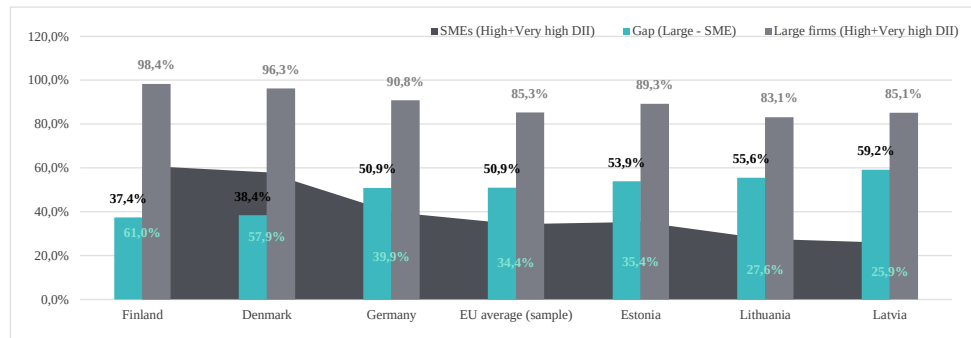


Figure 4. Digital Capability Gap: SMEs vs. Large Enterprises

Source: Eurostat (2023)

Figure 4 above shows that in the Baltic countries (Latvia, Lithuania, Estonia), the digital strength gap between SMEs and large enterprises exceeds 50 percentage points, and in Latvia, it is close to 60%. This "Baltic paradox" suggests that advanced infrastructure does not automatically lead to the diffusion of small and medium-sized enterprises, and that institutional friction and ability constraints are often centralised at the application level. It is more reasonable to understand that a single factor does not drive this gap, but instead that it results from a combination of structural, policy, and ability constraints. On the one hand, cross-domain digital investment offers economies of scale, and digital intensity is easier to accumulate and to turn into a reusable process in large enterprises. On the other hand, digital public investment initially falls at the government systems and infrastructure level, while adoption incentives and compliance adaptation lag on the SME side. At the same time, financing, human capital, and management capacity constraints make it more difficult for SMEs to convert compliance fixed costs into dilutable operating costs, ultimately widening the capacity gap. The three jointly point to the same conclusion: compliance friction has an obvious regressive nature, objectively raising the entry threshold, making it easier for existing large enterprises to expand across domains while hindering green small and medium-sized enterprises from entering the market on a larger scale. When innovators of sustainable solutions cannot bear the cost of cross-border compliance and process adaptation, the diffusion of green innovation will be limited, and the EU's green transformation goals will be indirectly constrained (Demirer et al., 2024). In summary, the result A confirms that the institutional root cause of the Adoption Gap focuses on the legal and organisational friction generated by legality, and inhibits the integration of SMEs into digital ecology in a regressive way, which provides an empirical starting point for the next section on how to encapsulate complexity and reduce friction in Institutional Middleware.

3.2 Result B: Middleware as a large-scale tool, the EU's institutional response

In light of the regressive nature of STFs and the compliance costs revealed by Result A, the European Union has adopted an active market-building strategy: to encapsulate compliance and adaptation risks in a fragmented environment by deploying Institutional Middleware. In the absence of this Middleware, entrepreneurs must bear the hidden costs of cross-domain expansion alone, including interpreting off-site rules, accessing identity systems, manually translating data semantics and adapting proprietary interfaces. Institutional Middleware aims to transform these decentralised fixed costs into reusable, auditable public infrastructure, so that scale no longer relies on the compliance capabilities of individual enterprises but on the "reproducible path of the market". Empirical evidence shows that this strategy is promoted collaboratively through financial support and standard formulation, and it jointly emphasises "scalability" and "replicability".

First, the funding tool aims to subsidise interoperability migration, lowering the threshold for system conversion and mitigating risks. Figure 5 shows that the Digital Europe Plan (DEP) emphasises deployment and diffusion more than Horizon Europe. Its budget directly subsidises the construction of Institutional Middleware (European Commission, 2022), thereby transforming the costs of compliant learning and trial-and-error into public investment.

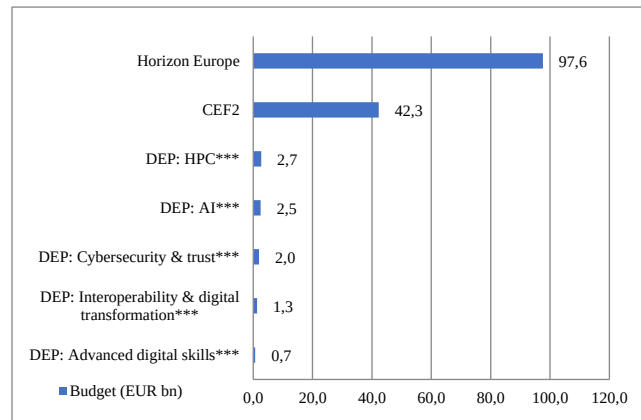


Figure 5. EU Funding Schemes as Institutional Middleware
Source: European Commission (2019).

For example, the European Digital Innovation Hubs (EDIHs) provide a "test before invest" environment, allowing SMEs to verify the scheme's compliance at low risk, thereby reducing the uncertainty premium caused by *Haftungsangst* (Vijayakumar & Davidova, 2025). At the same time, the NGEU Recovery Fund gradually bundles digital investment with green transformation goals to promote the formation of a "sustainable digital" demand-side market.

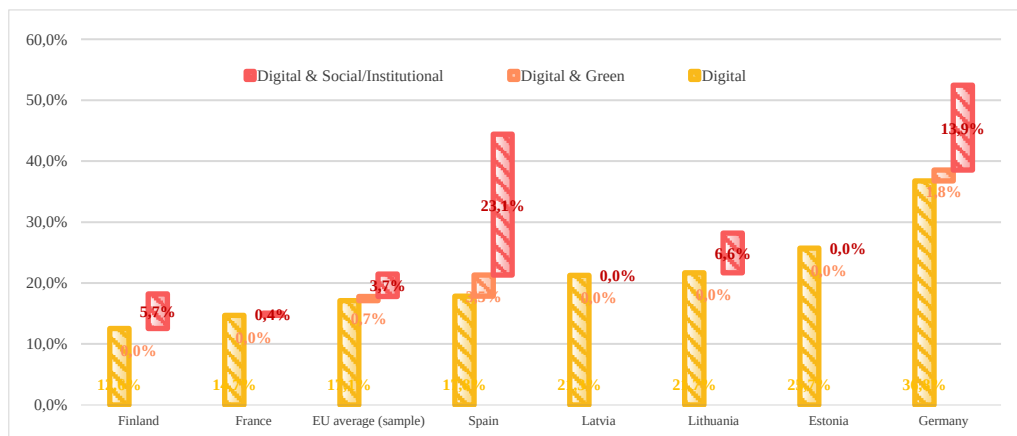


Figure 6. Overlap Between Digital, Green, and Social Funding in NGEU
Source: Bruegel (2023)

Figure 6 above shows that Spain, Germany and other countries invest funds in areas of digital and green overlap, such as digital monitoring and governance of energy efficiency, which means that Middleware not only reduces barriers to entry but also fosters the environment for scalable application scenarios and sustainable business models through fund allocation (European Commission, 2024b). In contrast, the Baltic countries show no overlap under the criteria for this label, which is more likely to reflect differences in policy design, classification criteria, or priority preferences rather than a lack of digital capacity. It suggests that transition economies still need to translate capital tools more clearly into support for the adoption and supply of reusable compliance paths for green entrepreneurship.

Secondly, the minimum interoperability mechanisms (MIMs) constitute the standard kernel of Institutional Middleware, which is promoted through networks such as OASC and "Living-in.EU" to curb fragmentation and supplier lock-in (Open & Agile Smart Cities, 2025). MIM1 (context information management, OMA NGSI-LD) reduces the cost of cross-city technology adaptation with a general API and context link mechanism, bringing the application closer to the expansion conditions of "one-time development, multi-place deployment"

(Bauer, 2022); MIM2 (shared data model) reduces "translation friction" through unified semantics and field structure, providing prerequisites for green data processing and compliance reporting automation; MIM3 (ecosystem transaction management) solidifies the credible boundaries of data sharing and service exchange through permissions, records and audit mechanisms, and responds to the core requirements for traceability in a high legitimacy environment (European Commission, n.d.-b). Funds and MIMs encapsulate "migration cost and risk exposure" and "adaptability complexity and semantic fragmentation," respectively, transforming interoperability from rhetoric into reusable infrastructure and laying the institutional foundation for the next section on procurement rules and urban cases on how to open up SME market opportunities further.

3.3 Result C: From interface to process, implementation at the urban level

Institutional Middleware is not only highlighted in Brussels' policy document; it is also being tested under real-world stress in urban laboratories across Europe. Barcelona and Bologna examine two complementary approaches. The former incorporates open standards and data ownership into procurement contracts. It shifts the competition structure to the market-access side. At the same time, the latter includes participation programmes and the Local Digital Twin (LDT) in the policy testing process to reduce uncertainty around innovation, trial, and error. Together, these cases show that only when Middleware is embedded into actual transactions and decision-making processes can it substantially reduce STFs and transform "compliance" from a burden into a vital condition for sustainable entrepreneurship.

In Barcelona, "Technological Sovereignty" was made a strict requirement within the procurement system, effectively incorporating the "agreement layer" of Middleware into the contracts and market access regulations (Calzada, 2019). The city council adopted open standards and, whenever possible, mandated the use of open-source software in bidding processes, emphasising that data generated by public services is a public asset owned by the city and its citizens rather than by suppliers (Ajuntament de Barcelona, 2018). The main aim of this approach is not merely to express a position but to reduce the structural advantage of supplier lock-in, thereby enabling smaller local enterprises to offer modular services around open interfaces. This lowers the proprietary adaptation costs needed to access the public market, facilitating the development and delivery of solutions such as energy savings, waste reduction, and green logistics (Ajuntament de Barcelona, 2018). Based on this, a testable hypothesis can be proposed: when urban procurement rules mandate open standards and interoperability, the costs associated with supplier lock-in decrease, entry barriers are lowered, and the participation and innovation potential of SMEs are more likely to increase (P1).

Bologna focuses on organisational interoperability and process reshaping. Its "Civic Imagination Office" enables citizen collaboration to obtain enforceable legal form by standardising participation procedures and promoting the signing of the "Patti di collaborazione", thereby transforming "participation" from loose opinions into structured input that can enter the governance process (Fondazione Innovazione Urbana, 2023). At the same time, LDT is positioned as a testing ground for policy and innovation. It not only carries 3D models, but also connects the simulation and evaluation of social and environmental variables, so that start-ups can test the impact of transportation, energy and other solutions on emissions and urban operation in a controlled environment, reduce the cost and responsibility exposure of trial and error in the real world, and then form a green innovation safe harbour closer to "scalable" (Comune di Bologna, 2023). This also supports a proposition: when cities provide digital twins or sandboxes as test environments, the risk of innovation failure is partially externalised, and the trial rate and iteration speed of green solutions are more likely to increase (P2). Further, when public data is clearly defined as a public product and can be called in compliance under the rules, it is easier to form a commercial closed loop of "data-model-service" to provide continuous impetus for the diffusion of green innovation (P3).

Overall, the experience at the city level shows that the key to Middleware is not the number of interfaces, but whether the procurement rules and collaboration processes can "encapsulate" compliance complexity into reusable infrastructure and redistribute market opportunities from a few large suppliers to a broader range of SMEs and sustainable entrepreneurs.

4. Discussion

Comprehensive analysis demonstrates that interoperability in the European Union has transcended technical dimensions to become a core economic enabling mechanism. The persistence of the aforementioned Adoption Gap stems from the fact that SMEs, often lacking administrative resources, face excessive transaction costs. Institutional Middleware aims to flatten this cost curve.

4.1 Insights from Transitional Economies: The Baltic Paradox

The Baltic Paradox provides a very explanatory contrast situation. The three Baltic countries have overall outstanding performance in the usability of digital public services, and their electronic identity and government portal systems are relatively mature. Accordingly, the proportion of enterprises that regard "insufficient digital infrastructure" as the primary investment obstacle is also low (European Investment Bank, 2023; European Investment Bank, 2025). But at the same time, the gap in digital strength between SMEs and large enterprises in these countries remains evident, particularly in Europe (Eurostat, 2023). This is the core of the "paradox": high-capacity and low-infrastructure barriers have not naturally led to broad digital deepening among SMEs. Figure 7 more directly reflects enterprises' feelings about the constraints imposed by "infrastructure availability".

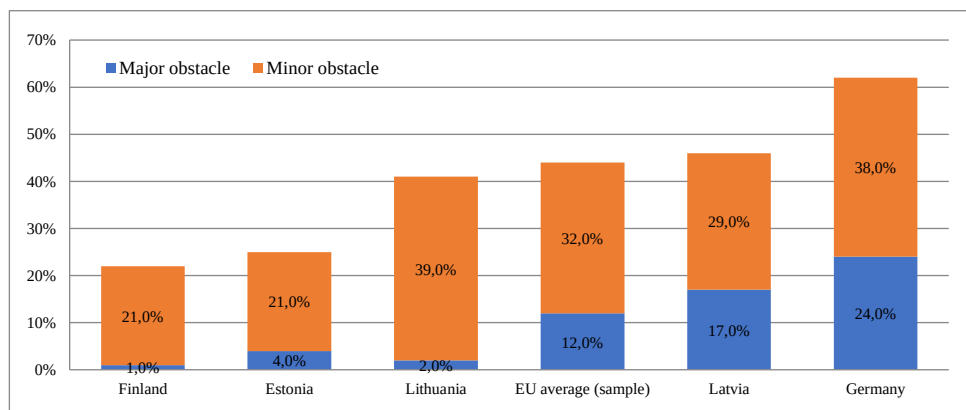


Figure 7. Digital Infrastructure as an Investment Barrier

Source: European Investment Bank (2025)

It can support the judgement that "the obstacles at the technical and infrastructure level are not prominent", but it cannot infer that the legal, organisational or semantic layers STFs are also low. Therefore, a more secure interpretation is that when infrastructure is no longer the most significant source of constraints on the enterprise side, the bottleneck limiting the further digitisation of SMEs is often more likely to focus on the ability formation process of the application layer and the organisational layer, such as end-to-end process integration, cross-domain compliance adaptation, and the continuous investment required to embed advanced digital workflows in daily operations.

To avoid a single causal explanation, this article views this paradox as the result of the superposition of multiple mechanisms. First, cross-domain digital investment naturally yields economies of scale and reuse. Data governance, process reengineering, and advanced analytical capabilities are more likely to accumulate and form replicable capabilities within large enterprises, making digital intensity more concentrated there. Secondly, even if digital investment in the public sector significantly improves overall capacity, it often prioritises the government system and infrastructure. If the adoption incentives for SMEs, compliance adaptation support, and the supply of reusable tools are relatively lagging, the notion that "the supply side becomes stronger" will not automatically lead to "SME side diffusion". At the same time, constraints related to financing, human capital, and management capacity will affect whether enterprises can convert the fixed costs of GDPR, eIDAS, and cross-domain process adaptation into manageable operating costs, thereby influencing SMEs' ability to invest in advanced applications such as AI and big data analysis. These mechanisms are not mutually exclusive, nor do they require strict prioritisation within the evidence scope of this article. Still, they collectively highlight a clear policy implication: for transition economies, the focus of institutional Middleware should shift from

merely expanding infrastructure to supporting adoption and capacity building for SMEs, such as standard compatibility advice, compliance service provision, and tool arrangements for migrating fixed costs in the sharing system, to prevent the diffusion of capabilities that are structurally blocked by enterprise scale (Ruža et al., 2024).

4.2 Governance as a Platform

A full-text analysis reveals that the EU interoperability agenda is shifting from technological enhancements to market-oriented institutional development. The ongoing adoption gap indicates that merely improving supply-side capacity does not automatically normalise demand-side adoption. This is because STFs reinforce legality requirements and process complexities, which translate into transaction costs and impose stricter, regressive constraints on SMEs. From this perspective, Institutional Middleware is a platform-based governance architecture: it aims to shift the burden of compliance and adaptation needed for cross-domain expansion from individual enterprises to reusable institutional pathways and public capabilities. This way, scale is no longer dependent on entrepreneurs repeatedly "manually solving compliance problems", but instead relies on an executable, auditable, and replicable institutional infrastructure.

In this platform-based landscape, standards, procurement rules, and capital networks function as "arrangements". Standard mechanisms (such as MIMs) encourage cross-domain adaptation, shifting from project-based customisation to reusable pathways, which reduces the marginal cost of semantic conversion and technology integration; procurement and data ownership clauses formalise open standards, hinder the feasibility of suppliers locking in and expanding SMEs to access the public market; capital and capacity networks support early migration costs and uncertainties through subsidies, experimental environments, and coaching mechanisms to share systems, fostering compatibility and capacity diffusion. The urban case further illustrates that this kind of platformisation does not happen automatically. Only when the institutional Middleware is genuinely embedded in the transaction and decision-making process can it significantly reduce friction and open the window of opportunities for sustainable entrepreneurship. For the entrepreneurial ecology, its importance is not to guarantee the "necessary success" of expansion, but to minimise the uncertainty of cross-city entry and compliance adaptation, making innovation costs more likely to shift from repeated compliance to product iteration, thereby providing more stable institutional conditions for scaling and replicating green solutions.

Conclusions

The research evidence in this study shows that the core bottleneck of the long-term "high availability, low adoption" dilemma in the EU Digital Single Market is not a lack of platforms or infrastructure, but rather structural Socio-Technical Frictions (STFs) caused by digital legitimacy requirements. In practice, this bottleneck manifests as legal requirements that must be enacted through end-to-end digital procedures (such as eIDAS-based identification and signatures, GDPR-compliant data processing, and auditable process tracking). These requirements generate frictions at the legal and organisational layers, which translate into fixed "legitimacy costs". Due to the high upfront investment and weak correlation with enterprise scale, these costs have a regressive effect: large firms can amortise them through specialised legal, compliance, and IT capabilities, whereas SMEs face them as a de facto market entry threshold. This also explains the adoption gap we have observed, where the demand-side penetration rate lags even with improved supply-side conditions, and underscores the importance of this restriction for sustainable small and medium-sized enterprises operating in a high-compliance environment.

Based on this diagnosis, the paper develops "Institutional Middleware" as an interpretive framework to explain how the EU attempts to transform fragmented compliance burdens into reusable public infrastructure. We do not treat "Institutional Middleware" as a fully estimated causal model, but instead offer a mechanism-oriented explanation supported by multiple sources of evidence and case illustrations, thereby clearly separating empirical support from explanatory content. Our analysis uncovers a pattern consistent with a mechanism across EU policy instruments and urban cases: (1) recurring legal and organisational frictions are apparent in user-reported barriers and abandonment behaviours; (2) these frictions create fixed costs with regressive effects on SME capabilities; and (3) EU policy instruments are increasingly employed as a coordinated chain of tools aimed at externalising part of the compliance burden.

Under this framework, we identify three complementary mechanisms. First, standards - specifically Minimum Interoperability Mechanisms (MIMs) - encapsulate semantic and technical complexity through reusable interfaces and shared specifications, thereby reducing integration costs and limiting vendor lock-in. Second, procurement operationalises openness by embedding interoperability and data governance requirements into market access rules; the Barcelona case illustrates how procurement clauses can lower entry barriers for small suppliers by making standards enforceable in actual transactions. Third, capital through funding instruments such as the Digital Europe Programme (DEP) and NextGenerationEU plays an enabling role. By subsidising early migration costs and supporting experimentation, it de-risks the adoption of new standards and mitigates the obstacle of fixed compliance costs for SMEs. Together, these elements reflect the EU's attempt to treat compliance as infrastructure.

Crucially, the sustainability dimension is not an add-on but a primary application domain, as legitimacy costs in this field have significant economic consequences. Under the EU's "Twin Transition" strategy, green entrepreneurship increasingly depends on the ability to meet requirements under the Corporate Sustainability Reporting Directive (CSRD) and other regulations through interoperable, auditable digital workflows. Institutional Middleware provides a practical design logic: translating sustainability reporting and monitoring requirements into interoperable data structures and auditable process modules. This allows compliance to become embedded, reusable, and closer to automation, ultimately reducing rather than amplifying entry barriers for green SMEs.

Finally, the transition process remains inconsistent. Germany's Haftungsangst (liability anxiety) shows that technical Middleware must be paired with legal clarity on liability boundaries. At the same time, the "Baltic Paradox" indicates that infrastructure alone cannot close the capacity gap without supporting capacity-building measures. Therefore, policy success should be assessed not only by service availability but also by the structural support provided to entrepreneurs driving the green transition. Future research can examine this framework more directly by measuring whether specific middleware deployments (e.g., procurement interoperability clauses or MIM-based implementations) decrease abandonment rates, reduce compliance costs, and increase SME participation in digital and green markets over time.

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Author Contributions: The authors contributed equally. All authors have read and agreed to the published version of the manuscript.

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