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Digitalization as a Key Factor of Competitiveness Under Sanctions and Geopolitical Pressure: A Typology of Digital Resilience and a Research Agenda

Maxim K. Izmaylov

Cand. Sc. (Economics), Docent, Associate Professor at the Graduate School of Industrial Management, Peter the Great St. Petersburg Polytechnic University, Polytechnicheskaya 29, St. Petersburg, 195251, Russia

*Corresponding author: Maxim K. Izmaylov, max78rus@ya.ru

Abstract: This study develops a typology of digital resilience under sanctions that reconceptualizes digitalization not as a uniform driver of competitiveness but as a configuration of strategic responses whose effectiveness depends on the alignment between the domain of digitalization, the type of sanction being addressed, and the institutional locus of the response. Existing scholarship has treated digitalization as either a generic productivity enhancer or a firm-level strategic choice, without theorizing how the sanction type conditions which digitalization strategies are feasible and which generate competitive advantage. The typology developed here identifies four domains of digital resilience — technological substitution, financial channel adaptation, platform reconfiguration, and data sovereignty — and maps each against the sanction type it addresses, the mechanism through which it operates, and the institutional conditions it requires. The framework is developed as a conceptual contribution with illustrative comparative evidence from Russia, Iran, and Venezuela, drawing on the logic of theory-building through multiple cases while acknowledging the limits of the available data. A critical analytical distinction is introduced between survival and competitiveness, and between three analytically distinct classes of actors: private firms, small and medium-sized enterprises, and systemic state corporations. The typology specifies the conditions under which survival-oriented digital resilience translates into genuine competitive advantage, and the conditions under which it does not. The study makes three contributions. First, it provides a conceptually rigorous alternative to universalistic accounts of digitalization by specifying the sanction-contingent conditions under which digitalization enhances competitiveness. Second, it demonstrates that different sanctioned economies develop structurally different digital resilience configurations. Third, it derives a testable research agenda that operationalizes each dimension of the typology.

Keywords: digital resilience; theory building; technological sovereignty; import substitution; survival versus competitiveness; systemic state corporations;

1. Introduction

The international business landscape has undergone a structural transformation that the existing theoretical apparatus was not designed to explain. For three decades, the dominant paradigm assumed that firms operate in an open global economy where technology, capital, and knowledge flow across borders with minimal friction. Digitalization was theorized as a universal driver of competitiveness because it enabled firms to reduce transaction costs, access global markets, and innovate at scale [1, 2]. This paradigm has collapsed for a growing number of economies. Sanctions, export controls, and geopolitical fragmentation have created a world in which access to technology is a political variable, not a market outcome [3].

The empirical record is theoretically puzzling. A meta-analytic investigation confirms that digital transformation significantly enhances firm competency, performance, and resilience in open economies [4]. A study of Chinese listed companies finds that digital transformation significantly improves economic competitiveness, with effects that vary by ownership structure and market concentration [5]. Yet when the same relationship is examined in Russia under sanctions, the results are null or negative: a panel study of Russian firms finds that digital transformation does not significantly affect productivity [6], and a separate study using spatial regression models reaches the same conclusion [7]. The same technology, deployed under different institutional conditions, produces opposite outcomes.

The existing literature offers two responses, neither satisfactory. The first treats the null results as evidence that Russian firms are not really digitalizing [8]. This explains the null result by assuming away the phenomenon. The second treats them as evidence that sanctions destroy the digitalization–competitiveness link [9]. This is theoretically coherent but empirically incomplete: it does not explain why some Russian firms have achieved substantial digital transformation [11, 12]. Firm-level evidence suggests that resilience is contingent on institutional embeddedness: state-affiliated and export-oriented firms reported more resilience, whereas non-strategic SMEs struggled with persistent financing and input constraints [10]. This points toward a more nuanced framework.

A critical analytical distinction that existing frameworks have not adequately theorized is the difference between survival and competitiveness, assessed at two analytically distinct levels. At the micro level, survival refers to the capacity of an individual firm to continue paying wages, shipping goods, and servicing obligations. At the macro level, survival refers to the capacity of the national economy to maintain export volumes, fiscal stability, and aggregate employment. These two levels can move in opposite directions. A firm may survive at the micro level because it receives state subsidies, enjoys privileged access to hard currency, or benefits from guaranteed procurement. Yet the same subsidies, privileged access, and procurement guarantees may simultaneously reduce macro-level competitiveness by diverting resources from more productive uses, distorting market signals, and creating a dual economy in which state-connected firms thrive while private firms stagnate. The critical insight is that micro-level survival achieved through state subsidies or market distortions can occur simultaneously with macro-level decline in overall economic competitiveness.

A second critical distinction concerns the class of actor. Under sanctions, it is analytically necessary to distinguish between private firms, which operate under market discipline and bear the full cost of adaptation; small and medium-sized enterprises, which face the most acute resource constraints and often lack access to state support [10]; and systemic state corporations, which are not market agents in the conventional sense but instruments of state policy, insulated from market discipline by guaranteed procurement, direct transfers, and political protection [14]. Conflating these classes under the generic label "firms" obscures the mechanisms through which digitalization affects performance and leads to theoretical confusion.

The present study responds to this theoretical gap by developing a typology of digital resilience under sanctions. The typology is built on a simple but consequential insight: digitalization addresses different sanctions through different mechanisms. When the sanction targets technology access, digitalization takes the form of technological substitution. When the sanction targets financial channels, digitalization takes the form of financial channel adaptation. When the sanction targets market access, digitalization takes the form of platform reconfiguration. When the sanction targets data flows, digitalization takes the form of data sovereignty. Each domain operates through a different mechanism, addresses a different sanction type, and requires different institutional conditions to succeed. Each also has a different relationship to competitiveness. The study makes three contributions. First, it provides a conceptually rigorous alternative to universalistic accounts of digitalization by specifying the sanction-contingent conditions under which digitalization enhances competitiveness. Second, it demonstrates that different sanctioned economies develop structurally different digital resilience configurations. Third, it derives a testable research agenda that operationalizes each dimension of the typology. The study is positioned as a conceptual contribution with illustrative comparative evidence, not as an econometric estimation. The harmonized firm-level panel linking financial data to technology adoption data is not yet available in open form, and the present study does not claim to have overcome this limitation.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical foundations. Section 3 develops the typology. Section 4 describes the methodological approach. Section 5 presents the comparative case analyses, applying all four domains to all three countries. Section 6 derives testable propositions. Section 7 specifies the research agenda. Section 8 concludes with implications for theory and policy.

2. Theoretical Foundations and Their Limits

The theoretical literature on digitalization and competitiveness rests on three pillars developed for open economies and not adequately adapted to sanctions. The Resource-Based View explains why digital capabilities generate competitive advantage [15], but assumes that firms can acquire these capabilities through market transactions. Dynamic Capabilities theory explains how firms reconfigure resources in turbulent environments [16], but assumes that reconfiguration is a managerial choice rather than a political constraint.

Institutional Theory explains how formal rules shape firm behavior [17], but assumes that institutions are stable background conditions rather than contested terrain. Each assumption breaks down under sanctions.

The RBV posits that sustained competitive advantage derives from resources that are valuable, rare, inimitable, and non-substitutable [15]. Under sanctions, access to foreign technology is closed, which means that domestic digital capabilities become genuinely rare and difficult to imitate [3]. The RBV would predict that this should increase the competitive advantage of firms that possess such capabilities. Yet the empirical evidence from Russia shows null or negative effects of digitalization on productivity [6, 7]. The RBV cannot explain this contradiction because it does not theorize the cost side of resource acquisition. When sanctions close access to foreign technology, the cost of developing domestic substitutes rises, and this cost may exceed the value of the competitive advantage the substitute generates. Firm-level evidence from Russia confirms that sanctions' effects are uneven, shaped by firm-level characteristics and political status, with important trade-offs between short-term stability and long-run efficiency [10].

Dynamic Capabilities theory extends the RBV by emphasizing that in turbulent environments firms must develop the capacity to sense, seize, and reconfigure resources [16]. Sanctions constitute precisely such turbulence, and digitalization functions as a reconfiguration mechanism [18]. Yet the Russian evidence shows that the firms with the strongest capabilities — systemic state corporations — are precisely those that have achieved the most substantial digital transformation [11, 12, 13], while small private firms lag behind. This raises a question the theory does not address: are the dynamic capabilities of state corporations genuinely superior, or do they reflect political access rather than organizational competence? The theory does not distinguish between capabilities built through market competition and those granted through institutional privilege. This distinction is critical under sanctions, where political access may be a more important determinant of digitalization than organizational competence. Recent research has extended this framework to incorporate political dynamic capabilities [69, 70].

Institutional Theory adds the insight that formal rules, regulatory frameworks, and government interventions shape the extent to which digitalization can be translated into competitive advantage [17]. The Russian government's response to sanctions — subsidies, registries of domestic software, industrial competence centers, and the national project "Data Economy" [21] — constitutes an institutional environment that either amplifies or constrains the digitalization–competitiveness relationship. Yet the theory treats institutions as background conditions rather than strategic arenas that firms actively contest. Under sanctions, institutions are being rebuilt in real time, and firms that can influence institutional design may gain advantages that have nothing to do with digitalization per se. Recent work on institutionalized digital resilience suggests that states govern these interfaces through controlled openness [20].

The synthesis of these three limitations points to a theoretical gap. Existing frameworks assume that digitalization is a firm-level strategy operating within a stable institutional environment and a functioning market for technology. Under sanctions, none of these assumptions hold. Digitalization becomes a configuration of responses involving firms, states, and international actors, operating across multiple domains, and shaped by the type of sanction being addressed. The theoretical contribution of this study is to specify this configuration space and to identify the conditions under which different configurations generate competitive advantage rather than mere survival.

3. A Typology of Digital Resilience Configurations

The typology identifies four domains of digital resilience, each addressing a different type of sanction through a different mechanism. The domains are not mutually exclusive, but they are analytically distinct because they involve different actors, resources, and institutional conditions. A critical feature of the typology is its explicit incorporation of the survival–competitiveness distinction and the class-of-actor distinction: each domain is evaluated not only on whether it enables survival, but on whether and under what conditions it generates competitive advantage for private firms, SMEs, and systemic state corporations respectively. The typology is presented in Table.

Table A typology of digital resilience configurations

Domain	Sanction addressed	Mechanism	Primary actors	Institutional condition	Relationship to competitiveness
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Technological substitution	Export controls on technology [3]	Replacing foreign software and hardware with domestic equivalents [21]	Systemic state corporations, large private firms [14]	State mandates, subsidies, procurement guarantees [21]	Contingent on cost-to-functionality ratio: enables micro-level survival of systemic state corporations; erodes macro-level competitiveness if domestic substitutes are more costly or less functional [24, 25, 27, 42]
Financial channel adaptation	Financial sanctions (SWIFT, dollar access) [65, 66]	Developing alternative payment systems that circumvent sanctioned infrastructure [28, 29]	Central banks, state oil companies [30, 59]	Regulatory tolerance, international partnerships [31]	Primarily survival-oriented: enables continued trade at micro and macro levels; creates internal market distortions that favor state-connected firms and may reduce macro-level competitiveness [31, 61]
Platform reconfiguration	Market access restrictions [32]	Building domestic digital platforms that substitute for foreign ones [48]	Domestic tech firms, state-backed ventures [49]	Market protection, user acquisition support [32]	Potentially competitive, but often survival-oriented: platforms may develop genuine capabilities if they face domestic competition; the Russian case shows that even market leaders may sacrifice global scalability for local survival, reducing macro-level competitiveness [32, 33]
Data sovereignty	Data flow restrictions [22]	Localizing data storage and processing within national borders [22]	State agencies, critical infrastructure operators [62]	Regulatory mandates, technical standards [62]	Primarily defensive: ensures regulatory compliance and data security; does not by itself generate competitive advantage at either level and may increase operational costs [62]

Notes. The sources cited in each cell refer to the numbered references in the Reference list. For the "Technological substitution" domain, the sanction type is documented in [3]; the mechanism and institutional conditions are described in [21]; the primary actors are analyzed in [14]; and the cost-to-functionality condition is documented in [24, 25, 27, 42]. For the "Financial channel adaptation" domain, the sanction type is documented in [65, 66]; the mechanism is described in [28, 29]; the primary actors are identified in [30, 59]; the institutional conditions are analyzed in [31]; and the relationship to competitiveness is discussed in [31, 61]. For the "Platform reconfiguration" domain, the sanction type is documented in [32]; the mechanism is described in [48]; the primary actors are identified in [49]; the institutional conditions are analyzed in [32]; and the relationship to competitiveness is discussed in [32, 33]. For the "Data sovereignty" domain, the sanction type, mechanism, primary actors, institutional conditions, and relationship to competitiveness are all documented in [22] and [62]. All web sources were accessed on 01.09.2026.

Technological substitution addresses export controls by replacing foreign software and hardware with domestic equivalents. The mechanism is substitution. The primary actors are systemic state corporations and large private firms with the scale to absorb fixed costs. The institutional condition is state mandates combined with subsidies and procurement guarantees. The Russian experience exemplifies this domain: the government has set the task of converting 80 percent of organizations in key sectors to Russian-made software by 2030 [21], and state organizations have achieved 68.72% localization in regional government bodies and 76.29% in federal bodies and state corporations [23].

The critical caveat is the cost-to-functionality ratio. High substitution rates do not automatically translate into enhanced competitiveness. The "cheap" phase of import substitution — replacing simple positions — has been exhausted, and further progress requires substantial investment in complex systems [24]. Business surveys consistently identify high cost, insufficient functionality, and migration complexity as primary barriers [42]. The cost of Russian licenses increased by 10–40% in 2025–2026, while hidden migration costs account for 30–50% of total cost of ownership [25]. Expert assessments indicate that the cost of transition will ultimately

be borne by consumers [26]. The oil and gas sector has already experienced significant cost increases [27]. These cost pressures mean that technological substitution may enable micro-level survival of systemic state corporations — the firm continues to operate — while simultaneously eroding macro-level competitiveness by increasing operational costs and reducing resources for innovation.

Financial channel adaptation addresses financial sanctions by developing alternative payment systems. The mechanism is circumvention. The primary actors are central banks and state oil companies. The institutional condition is regulatory tolerance combined with international partnerships. The Iranian experience exemplifies this domain: the country processes approximately \$9.9 billion in cryptocurrency transactions annually [28], with an estimated 80% of oil revenue settled through Tether [29]. Venezuela's PDVSA requires USDT prepayment for oil sales, with 75% of oil exports settled through USDT [30]. A systematic review identifies two models: state-controlled (Iran) and market-oriented (Venezuela) [31]. The same study establishes that cryptocurrencies can act only as an auxiliary rather than a systemic tool, limited by dependence on centralized infrastructure supervised by Western regulators [31].

The critical caveat is the relationship to competitiveness at both levels. The use of cryptocurrency settlement may enable a state oil company to continue exporting — micro-level survival — and may enable the state to maintain export revenue — macro-level survival — but it does not necessarily make the economy more competitive. The mechanism creates internal market distortions: access to alternative financial channels gives state-connected firms privileged access to hard currency and international markets, while private firms without such access face barriers. This creates a dual economy in which state-connected firms enjoy advantages not derived from superior efficiency but from political access. It is possible, in principle, for micro-level survival of state-connected firms to coexist with macro-level decline in overall economic competitiveness.

Platform reconfiguration addresses market access restrictions by building domestic digital platforms. The mechanism is replacement. The primary actors are domestic technology firms and state-backed ventures. The institutional condition is market protection combined with user acquisition support. The Russian experience partially exemplifies this domain: domestic platforms such as Yandex, VK, and Ozon expanded their market share following the exit of foreign competitors [32]. The IT sector has demonstrated the strongest adaptation to sanctions, with positive revenue dynamics while most other sectors exhibited zero or negative dynamics [33].

The critical caveat is whether domestic platforms develop genuine capabilities or remain dependent on protection. A platform that succeeds only because foreign competitors have exited may lose its market position if those competitors return. The Russian case illustrates this vulnerability with unusual clarity. Even the leaders of the platform market — Yandex, VK, and Ozon — have been forced to undertake corporate restructuring that splits them into "Dutch" and "Russian" parts, separating international assets and investor bases from domestic operations. Yandex, once the largest technology company in Russia and one of the few with genuine global ambitions, completed a complex divestment in which its international divisions were sold to a consortium of Russian investors, while its Dutch parent retained the international businesses under a new brand. VK has narrowed its strategic focus to the domestic market. Ozon has limited its international expansion. These restructurings represent a fundamental sacrifice of global scalability and access to international capital in exchange for local survival. The protection that enables survival also creates vulnerability by removing competitive pressure and cutting off access to global ecosystems. This suggests that platform reconfiguration may enable micro-level survival while reducing macro-level competitiveness by severing links to international capital, talent, and technology.

Data sovereignty addresses data flow restrictions by localizing data storage and processing. The mechanism is localization. The primary actors are state agencies and critical infrastructure operators. The institutional condition is regulatory mandates combined with technical standards. The Russian experience exemplifies this domain: the government has implemented requirements for personal data localization and developed technical standards for data exchange between state agencies [22].

The critical caveat is its primarily defensive nature. Data localization ensures regulatory compliance and enhances security, but does not by itself generate competitive advantage. It may increase operational costs by requiring duplication of infrastructure. The net effect on competitiveness depends on whether security and compliance benefits outweigh cost increases.

The typology thus incorporates a fundamental insight: different domains of digital resilience have different relationships to competitiveness, and these relationships must be assessed for each class of actor and at both levels of analysis. Conflating these domains under the generic label "digitalization" obscures these differences and leads to theoretical confusion.

4. Methodological Approach: Conceptual Development with Illustrative Comparative Evidence

This study develops the typology as a conceptual contribution with illustrative comparative evidence from Russia, Iran, and Venezuela. The approach is informed by the logic of theory-building through multiple cases [34, 35], but it is positioned as conceptual rather than strictly empirical. The study does not claim to fulfill the full requirements of Eisenhardt's method — which would require systematic, reliable, and triangulated empirical evidence across all cases — because such evidence is not available in open sources for all dimensions and all countries. Instead, the study uses the cases illustratively to demonstrate the theoretical dimensions of the typology and to generate propositions for future empirical testing.

The case analysis applies all four domains of the typology to all three countries, following the logic of structured-focused comparison. This balanced design allows for the identification of the conditions under which each domain is feasible and effective, and the conditions under which it is not. Even where data show failure or absence of a particular domain in a given country, this is treated as valuable evidence for the theoretical framework.

The analysis draws on peer-reviewed empirical studies where available [10, 33, 61, 67, 75] and on official statistical publications [40, 41, 21, 22] for quantitative documentation. Where only non-academic sources are available — particularly for corporate restructuring details and cost data — the analysis flags this explicitly and treats the figures as illustrative rather than definitive. The analysis also incorporates evidence on parallel imports as a mechanism that complicates the binary "domestic versus foreign" framing of technological substitution [36, 37, 38].

5. Comparative Case Analysis: All Four Domains Across Three Countries

Russia: Technological Substitution as State-Led Import Replacement

Russia has pursued technological substitution with substantial but uneven progress. Federal bodies and state corporations have achieved 76.29% localization in software, regional government bodies 68.72% [23]. Corporate cases demonstrate that comprehensive substitution is possible: Kalashnikov Group completed import substitution for all ERP systems [11], Rosatom achieved 92% import substitution in key software classes [12], and VTB reported that 95% of its IT systems are free from sanctions risks [13]. However, progress is concentrated in systemic state corporations. Private sector organizations in key economic sectors have reached only 51.1% localization [23]. The gap between federal bodies (76.29%) and private sector organizations (51.1%) is 25.2 percentage points — a structural bifurcation. The institutional conditions that enable substitution — mandates, procurement guarantees, dedicated funding — are present in state organizations and absent in private firms. The IT sector has emerged as the primary beneficiary of state support [33].

A critical finding is the cost-escalation mechanism. The "cheap" phase of import substitution has been exhausted [24]. Business surveys identify high cost, insufficient functionality, and migration complexity as primary barriers [42]. The cost of Russian licenses increased by 10–40% in 2025–2026 [25]. The oil and gas sector has experienced significant cost increases [27]. These pressures mean that technological substitution may enable micro-level survival of systemic state corporations while eroding macro-level competitiveness by increasing operational costs and reducing resources for innovation. A further complication is the role of parallel imports. Russia legalised parallel imports in March 2022, allowing goods to enter without the trademark owner's consent [38]. In Q1 2025, parallel imports amounted to \$6.8 billion, though declining month-on-month [37]. By late 2025, parallel imports fell nearly 50% year-on-year, to \$20.9 billion for January–November [36]. This mechanism complicates the binary "domestic versus foreign" framing: firms may maintain access to foreign technology through grey channels, which reduces the pressure for genuine substitution and may delay the development of domestic capabilities.

Iran: Technological Substitution and Platform Reconfiguration Under Prolonged Sanctions

Iran has pursued technological substitution across multiple domains. The country produces over 97% of medicines domestically [43] and has developed domestic missile technology [44]. In petrochemicals, Iran has shifted from importer to exporter of catalysts [45]. A domestic metro train was developed entirely with local technology, involving 25 knowledge-based enterprises [43]. The country has also developed domestic operating systems for mobile phones [46]. However, the depth of substitution remains limited: one assessment notes that "domestic production will never reach 100% localization, and even advanced countries have 20–30% foreign dependence" [47].

Platform reconfiguration in Iran has been substantial. Domestic super-platforms across urban transportation, e-commerce, and delivery services have positioned themselves as critical components of the digital infrastructure [48]. Iranian platforms have developed strategic platform forking capabilities, enabling them to identify new opportunities, forge international partnerships, and reorganize internally to manage parallel ecosystems [49]. The Iranian podcasting platform Shenoto intentionally forked to overcome market limitations [49]. This suggests that platform reconfiguration in Iran has generated genuine capabilities, not merely dependence on protection.

Venezuela: Technological Substitution and Platform Reconfiguration Under Crisis

Venezuela has pursued technological substitution primarily through free and open-source software. The national Canaima GNU/Linux operating system, developed over nearly two decades, is used in the educational sector, public administration workstations, and critical servers [50, 51]. The government has promoted the migration of public institutions to free software to strengthen technological independence and reduce dependence on foreign licenses [52]. Canaima GNU/Linux version 8.4 was launched in 2026 [51]. However, the scale of adoption remains limited, and the platform ecosystem is constrained by the broader economic crisis.

Venezuela: Platform Reconfiguration and Data Sovereignty

Platform reconfiguration in Venezuela has been shaped less by market dynamics than by state control. The government has developed the VenApp application, originally intended for public service management, which has been reconfigured with functions to inform on individuals under labels such as "suspicious" activities [53]. The Patria System, presented as a social protection platform, and VenApp together constitute a dual-use technological surveillance network [54]. The Chinese company ZTE played a central role in developing the database for the Carnet de la Patria, incorporating advanced capabilities for identification and massive data gathering [54]. This suggests that platform reconfiguration in Venezuela has been primarily oriented toward state control rather than market competition, which fundamentally distinguishes it from the Russian and Iranian cases.

Data sovereignty in Venezuela has been pursued through national internet exchange points (IXPs) and DNS security protocols. The IXP project enables local exchange of over 300 gigabits of data between ten companies, strengthening digital sovereignty and reducing latency [55]. Regional IXPs are being developed to ensure that "data remains stored within the borders of the Bolivarian Republic of Venezuela" [56]. The government has initiated DNSSEC protocol adoption for the .ve domain to protect critical infrastructure [57]. Venezuela has also emphasized data sovereignty in satellite communications, citing the Simón Bolívar and Miranda satellites [58].

Iran: Financial Channel Adaptation and Data Sovereignty

Iran's financial channel adaptation is the most extensively documented domain. The country processes approximately \$9.9 billion in cryptocurrency transactions annually [28], with an estimated 80% of oil revenue settled through Tether [29]. The central bank acquired at least \$507 million in Tether [59]. IRGC-linked entities received more than \$3 billion in cryptocurrency inflows in 2025 [60]. A systematic review identifies Iran as the state-controlled model of cryptocurrency use under sanctions [31].

Data sovereignty in Iran is manifested in the National Information Network (NIN), a closed infrastructure that enables the operation of internet services without connection to the global web [62]. The NIN is described as the most radical variant of digital autarky, oriented toward digital isolation from global information flows [62]. Data localization requirements mandate that foreign companies store data exclusively within Iran [62]. The government has developed the Kashef surveillance platform, which aggregates personal identity information with travel, citizenship, and telecommunications data [63]. The NIN project is linked to individuals and companies under US sanctions, including Fanap [64]. This suggests that data sovereignty in Iran has been pursued as an instrument of state control and security rather than as a mechanism for enhancing economic competitiveness.

Venezuela: Financial Channel Adaptation Under Crisis

Venezuela's financial channel adaptation has been shaped by the broader economic crisis and the need to maintain oil exports. PDVSA requires USDT prepayment for oil sales, with 75% of oil exports settled through USDT [30]. A systematic review identifies Venezuela as the market-oriented model of cryptocurrency use under sanctions, where private actors adopt cryptocurrencies in response to currency instability and remittance needs [31]. The primary use of cryptocurrency in Venezuela is the transfer of remittances, with a high correlation between migration flows and interest in Bitcoin [61]. This suggests that financial channel adaptation in Venezuela is more survival-oriented and less state-directed than in Iran.

Summary of Comparative Analysis

The balanced application of all four domains reveals distinct configurations across the three countries. Russia has pursued technological substitution primarily through systemic state corporations, with limited progress in the private sector and a growing cost burden. Iran has pursued technological substitution, platform reconfiguration, financial channel adaptation, and data sovereignty simultaneously, with platform reconfiguration generating genuine capabilities but data sovereignty oriented toward state control. Venezuela has pursued technological substitution through free and open-source software, financial channel adaptation through market-oriented cryptocurrency adoption, and data sovereignty through national internet infrastructure, but its platform ecosystem has been shaped primarily by state control. No single country has pursued all four domains with equal intensity or success, and the configurations reflect different institutional conditions and sanction types.

6. Testable Propositions

The typology generates seven testable propositions. The propositions specify the domain, the mechanism, the condition, the class of actor, the level of analysis, and the survival-competitiveness distinction.

Proposition 1: (Technological substitution and micro-level survival of systemic state corporations). In economies subject to export controls on technology, technological substitution enables the micro-level survival of systemic state corporations more than that of private firms, because state corporations have access to guaranteed procurement and dedicated funding that reduce the financial risk of substitution, whereas private firms bear the full cost without guaranteed demand.

Proposition 2: (Technological substitution and the cost-to-functionality condition). The positive effect of technological substitution on competitiveness is conditional on the cost-to-functionality ratio of domestic substitutes. When domestic software delivers functionality comparable to foreign alternatives at acceptable cost, substitution enhances competitiveness. When it does not, substitution may enable micro-level survival of systemic state corporations while eroding macro-level competitiveness through increased operational costs and reduced resources for innovation.

Proposition 3: (Financial channel adaptation and survival). In economies subject to financial sanctions, financial channel adaptation enables the survival of export-oriented state enterprises more than that of domestically oriented firms, because export-oriented enterprises face the most acute need for alternative payment mechanisms.

Proposition 4: (Financial channel adaptation and the micro-macro divergence). Access to alternative financial channels creates internal market distortions that give state-connected firms an advantage over private competitors in accessing hard currency, international markets, and government financing. This advantage is not derived from superior efficiency or innovation but from political access to circumvention infrastructure. As a result, financial channel adaptation may enhance the micro-level survival of state-connected firms while reducing macro-level competitiveness through the creation of a dual economy, the diversion of resources from more productive uses, and the distortion of market signals.

Proposition 5: (Platform reconfiguration and the sacrifice of global scalability). In economies subject to market access restrictions, platform reconfiguration enhances the competitiveness of domestic technology firms only if the protected platforms use the breathing space created by foreign exit to develop superior technology, user experience, and business models. If domestic platforms rely solely on protection — or if they are forced to sacrifice global scalability and access to international capital to survive locally — they may achieve micro-level survival while reducing macro-level competitiveness.

Proposition 6: (Data sovereignty and defensive resilience). In economies subject to data flow restrictions, data sovereignty enhances the competitiveness of firms in critical infrastructure sectors only if the security and compliance benefits of localization outweigh the increased operational costs. The proposition specifies that data sovereignty is primarily defensive and does not by itself generate competitive advantage.

Proposition 7: (Micro-macro divergence as a general phenomenon). Across all four domains of digital resilience, micro-level survival can coexist with macro-level decline in competitiveness. The conditions under which this divergence occurs include: (a) the presence of state subsidies or procurement guarantees that insulate firms from market discipline; (b) the creation of dual economies that privilege state-connected firms; (c) the sacrifice of global scalability for local survival; and (d) the escalation of costs without corresponding increases in functionality. The proposition specifies that measuring resilience only at the micro level may systematically overstate the competitiveness of the economy as a whole.

These propositions are conditional, not universal. They specify the conditions under which each domain is likely to enable survival versus competitiveness, for each class of actor and at each level of analysis.

7. A Research Agenda

The typology and propositions generate a research agenda with four components.

The first component is constructing a firm-level panel that links digital resilience strategies to performance outcomes. The Russian Financial Statements Database provides financial data for the universe of Russian firms [39], and the Rosstat continuous statistical survey provides representative data on technology adoption [40]. However, these sources are not currently linked at the firm level. Until such matching is possible, the propositions cannot be tested with firm-level panel data. A complementary approach would use survey data that capture perceptual and behavioral responses among Russian SMEs [10].

The second component is operationalizing the survival-competitiveness distinction at both the micro and macro levels. Micro-level survival can be measured through continuity of operations — revenue stability, employment maintenance, absence of bankruptcy. Macro-level survival can be measured through aggregate export volumes, fiscal balance, and employment rates. Competitiveness requires longer-term indicators: profitability relative to industry peers, market share growth, innovation output, and export performance.

The third component is operationalizing the sanction type, the digital resilience domain, and the class of actor as measurable variables. The typology specifies four sanction types, four domains, and three classes of actors. The cost-to-functionality ratio can be measured through total cost of ownership comparisons between domestic and foreign software, survey data on user satisfaction and functionality gaps, and analysis of migration and maintenance costs. The sacrifice of global scalability can be measured through changes in international revenue share, foreign listings, and cross-border acquisitions.

The fourth component is identifying exogenous variation in the adoption of digital resilience strategies. The 2022 sanctions provide an exogenous shock that differentially affected industries based on pre-shock exposure. A difference-in-differences design would provide credible identification of the causal effect of digital resilience on competitiveness — provided that the firm-level panel data can be constructed.

8. Implications for Theory and Policy

The typology has implications for theory. The first is that digitalization is not a single phenomenon. Existing frameworks treat digitalization as a generic capability. The typology shows that digitalization is a family of strategies, each addressing a different constraint through a different mechanism and requiring different institutional conditions. The second implication is that the effectiveness of digitalization depends on alignment, not on level. A firm that has adopted advanced technologies but has not aligned them with the sanctions it faces will not benefit from digitalization. The third implication is that the survival-competitiveness distinction is analytically essential, and it must be assessed for each class of actor and at both the micro and macro levels. Conflating survival with competitiveness leads to theoretical confusion and policy error. The fourth implication is that institutional conditions are constitutive, not contextual. The conditions that enable one domain may constrain another, which means that digitalization policy involves trade-offs.

The policy implications follow from the typology. The first is that governments should prioritize domains of digital resilience based on the sanction types they face. The second is that policy instruments should be matched to domains. Technological substitution requires mandates, procurement guarantees, and dedicated funding; financial channel adaptation requires regulatory tolerance and international partnerships. The third is that the cost-to-functionality ratio should be explicitly incorporated into substitution policy. The data from Russia show that cost escalation is already eroding the benefits of substitution [27, 42]. The fourth is that the trade-offs between domains should be managed explicitly. The state mandates that enable technological substitution may suppress the market competition that enables platform reconfiguration. The fifth is that financial channel adaptation should be designed to minimize internal market distortions. Policy should ensure that alternative payment mechanisms are accessible to private firms on equal terms. The sixth is that policy evaluation should distinguish between micro-level survival and macro-level competitiveness. Success at the firm level does not necessarily indicate success at the economy level.

The study has limitations. The empirical evidence is illustrative and comparative rather than causal. The typology is developed conceptually rather than tested through econometric estimation. The propositions are specified but not tested. These limitations reflect the current state of data availability. The study is positioned as a conceptual contribution that specifies the conditions under which digitalization enhances

competitiveness under sanctions and provides the framework for future empirical testing. The typology offers a generalizable framework for understanding digital resilience under conditions of technological isolation.

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