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ADDRESSING THE PRODUCTIVITY PARADOX IN SMALL STATES THROUGH FEEDBACKED SHOCK-SENSITIVE SCENARIO-BUILDING

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Abstract. Estonia ranks among the world's top performers in digital government and startup ecosystems, yet its labour productivity stands at ~77.5% of the EU average and is drifting further from the government's target of 110% by 2035. We argue that this productivity paradox is best understood as a failure of national innovation system coherence. Using an intuitive-logics scenario methodology extended with design science and feedbacked shock-sensitivity testing across 26 events, we develop four scenario trajectories for Estonia's 2035 productivity outcome along the dimensions of collaborative capacity and institutional implementation capacity, ranging from continued drift to convergence towards the target. The analysis reveals three coherence failures: a translation gap between digital infrastructure and private-sector productivity, a structurally disconnected startup sector, and an unresolved valley of death at technology readiness levels 4–7. We suggest that economy-wide productivity requires complementary investment in management quality, translational infrastructure, and cooperative networks that allow innovation to diffuse beyond the highest-performing actors.

Keywords: national innovation systems, productivity growth, small open economies, design science research, systems architecting, scenario planning, innovation diffusion, resilience

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1. Introduction

Estonia occupies an unusual position in the comparative innovation literature. By most conventional measures, it is a post-Soviet success story: ranked among the top performers globally for digital government, boasting a disproportionate number of technology unicorns relative to its population size, and hosting one of the most vibrant startup ecosystems in Central and Eastern Europe (StartupBlink 2026). Yet its labour productivity stands at approximately 77.5% of the EU average, a figure that has declined in recent years rather than converging towards the government's stated target of 110% by 2035 (European Commission 2024, Statistikaamet 2024). The digital state and the productive economy appear to be in dissonance.

This divergence is what we call the small-state productivity paradox. It is not unique to Estonia: the broader literature has long noted that innovation system strength does not translate automatically into firm-level or economy-wide outcomes (e.g. Fagerberg and Sapprasert 2011, Bui et al. 2025). What makes Estonia theoretically interesting is the specificity of its configuration: a deliberately engineered digital infrastructure of world-class quality coexisting with a private sector that has not absorbed its productivity potential; a startup concentration of global significance that remains structurally disconnected from the majority of the economy; and a management quality deficit that limits firms' capacity to translate available technology into sustained value creation (OECD 2024a, Vadi et al. 2026).

This paper argues that Estonia's productivity paradox is best understood as a problem of national innovation system (NIS) coherence. Drawing on scenario analysis, systems thinking and design science methodologies, and a comparative examination of small-state NIS configurations, we propose a two-axis framework that positions NIS measures along the dimensions of collaborative capacity and institutional implementation capacity and apply this framework to the Estonian case. A method for testing the framework under internal and external shocks is developed, applied, and analysed. Our argument is that both top-down (strong institutions) and bottom-up (incentives, engagement, cooperation and a self-policing culture among citizens) elements are needed to raise productivity and overcome the middle-income trap in a small state. High performance in individual NIS components (e.g. digital infrastructure, R&D intensity, startup formation) does not produce economy-wide productivity gains when the components are not institutionally aligned, i.e. when the innovative activity of leading actors does not diffuse through the system to raise the productivity floor for the broader economy.

This paper is based on an earlier policy report prepared by the authors (Valtna, Lilo and Summatavet 2026). The report presented the initial scenario framework, empirical observations, and policy recommendations. The present article develops these original results into a theory-informed research framework by integrating contemporary literature on NIS, institutional implementation capacity, innovation diffusion, and strategic foresight, thereby extending the original work from policy analysis to a generalisable contribution to small-state productivity research.

This paper addresses three research questions that follow from this paradox.

RQ1: What are the axes along which small-state NIS coherence varies, and how can these be operationalised based on the existing literature?

RQ2: What are the specific mechanisms through which Estonia's NIS coherence failures produce the productivity paradox?

RQ3: What development trajectories does Estonia face under different coherence configurations, and how robust is each trajectory to external and internal shocks?

The paper proceeds as follows: Section 2 establishes the theoretical foundations and coherence gap in the NIS literature; Section 3 maps comparative cases (Ireland, Singapore, Iceland); Section 4 introduces the methodology; Section 5 applies the framework to Estonia; Sections 6 and 7 discuss implications, limitations, and conclusions.

2. Literature review

This section reviews the theoretical foundations of NIS research, small-state configurations, and the coherence gap that motivates this paper's analytical framework.

2.1. National innovation systems: theoretical foundations

In the classical NIS literature, innovation is the principal driver of productivity growth and structural transformation. The concept of NIS emerged from the recognition that innovation is not generated by firms, universities, or governments in isolation, but through interactions among organisations, institutions, markets, and policies (Freeman 1987, Lundvall 1992, Nelson 1993, Edquist 1997). Innovation is understood as a nonlinear, evolutionary, and path-dependent process in which learning, experimentation, and knowledge exchange occur across organisational and sectoral boundaries. Consequently, productivity growth depends not only on the availability of resources, but also on the capacity of the wider system to generate, diffuse, adopt, and commercialise knowledge.

While NIS theory has successfully established innovation as a systemic phenomenon, it provides limited guidance regarding how small open economies convert innovation capability into broad-based productivity growth under conditions of external dependence and uncertainty.

The NIS framework was built on large industrial economies, where the central question was how institutional configurations shaped technological change across broad industrial fronts (Freeman 1987, Nelson 1993). Edquist (1997, 2011) advanced the framework by identifying systemic failures, i.e. conditions in which individual components perform adequately but their interactions do not. Small open economies, facing external dependence and limited institutional scale, are particularly exposed to such failures. This creates the coherence gap the present paper seeks to address: a system can score highly on individual components while still failing to convert these into economy-wide productivity gains.

2.2. The role and limitations of small states

Innovation rarely follows a linear path from invention to economic impact. Knowledge creation, adoption, diffusion, and commercialisation occur through iterative interactions among firms, institutions, investors, and users (Edquist 1997, Caraça et al. 2009). This suggests that generating innovation and diffusing innovation are distinct challenges. Håkansson and Waluszewski (2002, 2018) conceptualise innovation as a sequence of interconnected settings involving development, production, and use, each requiring different infrastructures, relationships, and institutional arrangements. The transition from one setting to another is frequently more difficult than invention itself. These bottlenecks are reinforced by the dynamics of technology adoption. Sociotechnical transition research further demonstrates that innovation adoption is shaped by interactions between technological niches, incumbent regimes, and broader societal landscapes (Geels and Schot 2007). The process can be accelerated or hindered by specific intervention points within the system, including infrastructure, regulations, incentives, and coordination mechanisms (Kanger et al. 2020).

A recurring challenge is the 'valley of death', where promising technologies fail to progress from development to market deployment due to financing, coordination, and capability gaps (Auerswald and Branscomb 2003, Owen et al. 2019). The diffusion of innovations depends on a sufficiently large pool of adopters willing to absorb uncertainty and experiment with new solutions (Moore 1991). These challenges are amplified in small economies, where capital pools are shallower and fewer actors can support long innovation cycles.

Innovation and growth are further shaped by power-law dynamics, where a small number of firms generate a disproportionate share of economic value while most experiments fail to scale (Crawford et al. 2015). Ecosystem research suggests that such outcomes emerge from individual firm capabilities as well as interactions among specialised actors, complementary assets, and network structures (Jacobides et al. 2018).

The challenge is not unique to small states: Draghi (2024) identifies weak innovation diffusion and commercialisation as a broader European competitiveness problem. Europe performs relatively well in research, technology development, and product creation, yet struggles to achieve widespread adoption and productivity gains. Small economies must compensate through deliberate coordination, ecosystem orchestration, and international integration. In small economies, these constraints may emerge earlier, as limited scale can weaken development and production stages through insufficient testing environments, specialised suppliers, pilot customers, and translational infrastructures.

The literature suggests several mechanisms for overcoming these constraints. Mazzucato (2014) emphasises mission-oriented investment and public-sector market shaping, Perez (2002) highlights institutional alignment during technological transitions, and Li et al. (2025) stress dynamic capabilities in sensing opportunities and adapting resources. Similarly, smart specialisation seeks to concentrate resources

around regional strengths and entrepreneurial discovery processes (Foray 2014, McCann and Ortega-Argilés 2015). While these approaches generate important learning effects, implementation outcomes have been uneven because they depend on coherent intervention portfolios that address multiple systemic barriers simultaneously rather than on isolated policy instruments (Wieczorek and Hekkert 2012). Strategic prioritisation alone is insufficient without complementary capabilities for coordination, execution, and diffusion.

The implication for the innovation systems of small states, developed most fully by Edquist and Hommen (2008) in their ten-country comparative study, is that small NISs are necessarily more selective than large ones: they must develop coherent specialisation strategies supported by institutions that facilitate knowledge flows across a narrower but deeper innovation base, rather than across the board.

2.3. The coherence gap: what the literature implies but does not theorise

The dominant tradition in NIS scholarship treats these systems primarily as performance machines: configurations of actors, institutions, and linkages whose value is measured by their contribution to economic growth. A large volume of work has measured NIS dimensions and analysed their relationship to growth outcomes (Lee et al. 2021), with more recent contributions extending this to the firm level: stronger NIS environments encourage firms to invest more in intangible assets, now considered the primary drivers of economic resilience and value creation (Bui et al. 2025). The causal logic is systemic and straightforward: robust national innovation support catalyses corporate innovative activity by improving the expected returns to knowledge investment.

This performance-centred framing rests on an assumption that is increasingly difficult to sustain: that aggregate innovation system strength translates reliably into economy-wide outcomes. Recent evidence cuts against this assumption in two distinct ways. First, the NIS-to-firm-investment relationship is systematically moderated by governance quality, inequality, and workforce demographics, meaning that two countries with equivalent NIS scores can produce very different firm-level outcomes depending on their structural context; second, and more directly, stronger political institutions related to innovation can, under certain conditions, crowd out private intangible investment rather than stimulate it (Bui et al. 2025). A system that is strong in aggregate may contain internal contradictions that suppress the very behaviour it is designed to encourage.

The institutional literature provides the clearest explanation for these differences. Torres de Oliveira et al. (2022) show that institutional complementarities (the degree to which different institutional elements reinforce rather than contradict each other) shape whether firms' external knowledge search is productive or whether they retrench into closed strategies. Kafka and Kostis (2024) find that institutional weakness and uncertainty compound each other in suppressing domestic firms' innovation performance, while simultaneously creating opportunities that internationally mobile actors exploit: a domestic/foreign asymmetry that can make aggregate metrics look

healthy while underlying interaction failures persist. Casadella and Tahi (2025) extend this further, arguing that a system can be innovative in aggregate while remaining incoherent at the level of distribution and institutional alignment.

At the policy level, the same pattern appears. Howoldt (2024) finds that systemic instruments, most concerned with actor linkages and coordination, are selected more in response to institutional membership than to diagnosed system needs. Park et al. (2024) identify the result as policy patching: functional completeness without systemic coherence. Kivimaa and Kern (2016) add that transitioning to more coherent configurations requires active destabilisation of incumbent arrangements, which is politically most difficult. Karpińska's (2020) analysis of Polish innovation policy illustrates the consequences: substantial investment produced insufficient returns not because actors or resources were absent, but because the institutional arrangements linking them were not functionally complementary.

Put simply, NIS performance depends not primarily on the strength of any single component but on the degree to which components operate in a mutually reinforcing manner. Bui et al. (2025) call this the need for strong but flexible in-country institutions; Howoldt (2024) identifies it as the gap between instrument choice and system need; Torres de Oliveira et al. (2022) frame it as institutional complementarities at multiple levels; Kivimaa and Kern (2016) name it the political challenge of coherent policy mixes; Karpińska (2020) captures it as the unintended consequences of misaligned policy ambition and institutional implementation capacity. The present paper takes up this gap by dividing coherence into two operational axes and using their intersection to construct a scenario matrix that can be stress-tested against plausible disruptions.

3. Empirical literature

3.1. Comparative cases: ceiling/floor dynamics in small states

The cases of Ireland, Singapore, and Iceland discussed in this section are chosen to illustrate distinct NIS configurations that each illuminate a different aspect of the coherence problem. Each case maps differently onto the framework developed in this paper, with collaborative capacity and institutional implementation capacity as the deciding factors for the success of NIS measures.

3.1.1. Ireland: foreign direct investment (FDI)-led growth and the translation gap

Ireland's NIS is built on attracting FDI: the state uses tax policy, investment promotion, and educational investment to attract innovative multinational companies (MNCs), functioning primarily as a market shaper rather than a system builder (O'Malley et al. 2008). Institutional implementation capacity is high, and the state executes its chosen strategy effectively, but the model structurally bypasses domestic collaborative capacity. MNCs do not need domestic knowledge networks to operate, and so none develop. The result is a persistent translation gap between the innovative

ceiling set by foreign firms and the productivity floor of the domestic economy (O'Malley et al. 2008, Doran et al. 2014).

3.1.2. Singapore: directed state capacity and the scale-up ceiling

Singapore represents directed state capacity: deliberate public investment, coordinated industrial policy, and a sequenced upgrading strategy have shifted the economy from technology adoption towards technology creation (Wong and Singh 2008, Lee et al. 2024).

The state addressed opportunity and network failures in frontier sectors by identifying anchor tenants, stimulating venture capital markets, and positioning Singapore as a node connected to global innovation hubs rather than competing with them.

In Singapore's case, collaborative capacity is largely state-manufactured rather than culturally embedded: the network structures that make ecosystems function are constituted by state design rather than emerging endogenously from actor behaviour. The system's coherence is high where state coordination reaches and lower where it does not: the floor is well-maintained, but the capacity to multiply innovative actors beyond the state-championed cohort and raise the ceiling has remained constrained (Lee et al. 2024).

3.1.3. Iceland: niche specialisation and the diffusion constraint

Iceland's recent past illustrates the inverse configuration: high collaborative capacity within a densely networked financial sector, combined with insufficient institutional implementation capacity to monitor or regulate what that cooperation was producing. The liberalisation of financial markets in the late 1980s fostered an adventurous innovation culture and rapid sectoral growth, but governance arrangements failed to keep pace. The regulatory authority remained weak while the banking sector grew tenfold, and close ties between banks, the media, and politicians produced state capture rather than oversight (Sigurjonsson 2010, Wade and Sigurgeirsdottir 2012). The 2008 collapse is the sharpest available illustration that collaborative capacity without implementation capacity is not merely insufficient but also dangerous. For small states, the lesson is that foresight and regulatory reach are not optional complements to networked cooperation but preconditions for it.

Across these three cases, a consistent pattern emerges: NIS coherence failures may take different forms depending on which axis is weak, but in each case the result is the same: innovative capacity concentrates at the ceiling, often without raising the floor. Section 4 introduces the methodological framework through which this dynamic is examined in the Estonian case.

3.2. Research gap

The empirical picture developed above points to a gap in the existing literature. The NIS framework provides a vocabulary for describing the components of innovation systems and for diagnosing their individual failures, but it does not provide a systematic framework for analysing the degree to which those components are internally aligned.

The three comparators illustrate this gap. Ireland's NIS is highly coherent within its FDI-attraction model but incoherent in the connection between that model and the development of the indigenous economy. Singapore's NIS is highly coherent in the sectors and firms it has deliberately built but lacks the distributed institutional implementation capacity that would generate broad-based innovative activity. Iceland's NIS is coherent within its resource-based niche clusters but lacks the cross-sector architecture that would connect niche innovation to the broader economy. Each represents a system that performs well on its own terms while failing to produce the kind of economy-wide, floor-raising productivity growth that the NIS literature treats as the ultimate objective.

4. Methodology

The present research takes the stance that the challenge of improving productivity is the responsibility of policymakers. Scenario planning is chosen as the primary tool for conveying the knowledge obtained. Design science and systems architecture methods are used to overcome the shortcomings of the methodological tools.

4.1. Scenario planning methods

The practical challenge of improving productivity in a small open economy requires a methodological approach that is comprehensive, repeatable, interactive, and capable of supporting decision-making under uncertainty. The task is not only analytical but also organisational: decision-makers must engage with complex interdisciplinary evidence within a limited time while operating in a turbulent geopolitical environment. While scenarios have high potential to meet these requirements, the solution needs to be adapted to a dynamic environment. Thus, instead of static narratives, the solution needs to provide dynamic sociotechnical trajectories subject to feedback effects, adaptation processes, and internal and external shocks.

The underlying scenario methodology employed in this study builds primarily on the intuitive logics school of scenario development (Wack 1985, Schwartz 1997, van der Heijden 2005), which uses critical uncertainties to construct a set of internally coherent alternative futures. As this approach remains methodologically open, it provides limited guidance on how to integrate feedback mechanisms, stakeholder engagement, and shock-response analysis into a coherent process (Postma and Liebl 2005, Bishop et al. 2007).

Scenario development and systems thinking. The present study addresses a normative and transformative question (Börjeson et al. 2006): understanding the barriers to productivity growth and identifying pathways towards a desired future state. The two settings differ from Ward and Schriefer's (2003) strategic, exploratory scenario study in two important respects. First, whereas relevant knowledge in a corporate setting is largely embedded within the organisation, the productivity challenge requires combining external academic knowledge, policy objectives, and decision-making authority distributed across multiple actors. The commissioning ministry defines the policy objective, the academic team develops the analytical framework, and implementation remains the responsibility of policymakers. Second, the complexity of the challenge requires extensive external knowledge sourcing through desk research rather than participatory data collection (van Notten et al. 2003). Consequently, while continuous interaction with decision-makers is not feasible, their engagement remains essential for the uptake and application of the knowledge generated during the project (Rowland and Spaniol 2021). Decision-maker engagement therefore becomes a design requirement of the artefact rather than merely a dissemination activity.

Along the same lines, the system dynamics framework (Kunc 2024), including the use of 2 × 2 scenario matrices, system modelling, and feedback loops, differs from the present study in its treatment of stakeholder interaction and adaptive response mechanisms. Consequently, the resulting feedback processes and shock-response analyses are distinct.

Kunc (2024) and Ward and Schriefer (2003) both demonstrate prior integration of scenario planning, systems thinking, and stress-testing, but in settings that differ significantly from the present one. In what follows, we address the task at hand as a problem to be solved. The research is positioned at the intersection of scenario development, solution design, and systems architecture for a dynamic, complex system. The design specifications for the present approach are therefore defined by what existing methods leave underdeveloped: feedback mechanisms, shock testing, adaptability to environmental conditions, and decision-maker engagement. (Independently, in Valtna et al. (2026), the authors have developed a solution that shares multiple similar structural elements with Smulders et al. (2026).)

4.2. Design science problem-solving method

The study applies the design science problem-solving method (Romme 2003, Romme and Holmström 2023) to develop an interactive scenario artefact for policymakers. Rather than producing only analytical findings, the method requires the construction and validation of a usable tool: a scenario-based decision-support model that integrates productivity diagnostics, NIS analysis, and shock-sensitivity testing.

The artefact was developed iteratively. The intuitive logics framework served as the baseline, with its limitations, identified in Section 4.1, defining the design specifications. The systems architecture approach (Rechtin and Maier 2010) provided the organising principle: defining the structure, relationships, and governing

principles of the artefact to achieve coherent behaviour under uncertainty, integrating economic, institutional, technological, and social dimensions while maintaining transparency between elements.

The resulting artefact maps the key drivers and barriers to productivity in a small open economy, defines the two scenario axes, develops four scenario trajectories, and stress-tests them against 26 endogenous and exogenous shocks. For each shock, the tool identifies the directional effect on the scenario matrix, the societal groups that gain and lose, and the restoration mechanisms available to policymakers. The artefact was tested with academic researchers and practitioners from the Ministry of Economic Affairs and Communications and refined based on their feedback. Development continues as new factors emerge.

4.3. Data and sources

The study combines academic literature, policy documents, statistical indicators, industry reports, and expert assessments to analyse productivity growth in a small open economy. Academic sources provided the conceptual foundations for NISs, innovation diffusion, ecosystem development, sociotechnical transitions, resilience, and scenario planning. Empirical evidence was drawn primarily from publications by the OECD, the European Commission, the IMF, and Statistics Estonia, complemented by national studies on management quality, startup ecosystems, and productivity performance.

Rather than relying on a single dataset, the research synthesises evidence from multiple sources and levels of analysis. The collected material was used to develop the operationalised productivity model, identify key observations and paradoxes, define the scenario axes, and construct the shock-testing framework. The resulting artefact therefore represents an integrated evidence-based synthesis designed to support strategic decision-making under conditions of uncertainty.

5. Results: Estonia's NIS in the coherence space

5.1. System-level model of small-state productivity

Productivity definitions. The OECD (2001) defines productivity as the ratio of outputs to inputs used in production and identifies productivity growth as one of the principal long-term drivers of economic prosperity and higher living standards. At the same time, the OECD Productivity Manual (2001) and Stiglitz et al. (2009) acknowledge that productivity indicators are imperfect proxies for economic performance, as they measure realised outputs rather than the underlying capabilities that generate future growth. Innovation investments, organisational learning, and societal effects, including institutional reforms, education, and knowledge creation, may temporarily reduce measured productivity while simultaneously strengthening long-term productive capacity.

The scale-dependent characteristics highlighted in Section 2 suggest that productivity growth in small open economies depends not only on innovation capability itself, but also on the coherence with which knowledge, institutions, policies, and resources are translated into economy-wide productivity gains.

Operationalised productivity model. Productivity in this study is treated as a system-level outcome generated through the interaction of firms, households, the public sector, and capital providers. Firms are the primary creators of productivity through value added, exports, innovation, and reinvestment. However, Estonia has largely exhausted the convergence model based on lower labour costs and efficiency gains. Future growth depends on moving towards higher-value products, knowledge-intensive activities, digitalisation, and stronger positions in global value chains.

Households contribute through skills, adaptability, entrepreneurship, and labour quality. Given Estonia's demographic constraints, future gains depend less on labour quantity and more on better utilisation of human capital, continuous learning, and movement into higher-productivity activities.

Capital providers, including domestic and foreign investors, enable technological upgrading and scaling. The key challenge is not the availability of capital itself, but its effective allocation towards productive and innovative activities. Consequently, future productivity growth depends primarily on improving cooperation, translating innovation, and strengthening institutional capabilities rather than on accumulating additional resources alone.

The public sector contributes to productivity primarily through institutional implementation capacity rather than direct value creation. Its highest-leverage role is to establish predictable rules, impartial governance, and efficient public services that enable cooperation between firms, researchers, investors, and citizens. In small open economies, where resources and actors are limited, generalised trust (Rothstein and Uslaner 2005) becomes a critical productive asset. Trust lowers transaction costs, accelerates knowledge exchange, facilitates collaboration beyond personal networks, and increases society's capacity to coordinate long-term investments. Consequently, the public sector's greatest contribution to well-being may not be the provision of capital itself, but the creation of institutional conditions that allow knowledge, capital, and talent to be combined to generate sustained productivity growth.

Productivity paradoxes and systemic tensions. Having defined productivity, we proceed to examine the current setting and how past decisions shape today's productivity outcomes. The analysis revealed several observations and tensions that suggest Estonia's productivity challenge is not primarily a question of missing resources, but of how existing resources are organised, translated, and deployed across the economy.

Varblane and Varblane (2010) operationalise productivity in the Estonian context through labour productivity measured as value added per employee, while further decomposing value added into labour costs, capital replacement costs, and residual income. This approach highlights an important distinction between the creation of value and the capacity to retain resources for future investment and development. Their analysis demonstrates that productivity differences are shaped by technology

as well as economic structure, value-chain position, managerial capability, and the ability to generate residual income for reinvestment.

Recent economic developments indicate that Estonia's productivity challenge is partly structural rather than cyclical. The loss of eastern export markets, increasing geopolitical uncertainty, demographic pressures, and the energy transition have exposed vulnerabilities in the economic model (European Commission 2024, IMF 2025). At the same time, many Estonian firms continue to operate in lower value-added segments of global value chains, limiting their ability to accumulate the residual income needed for reinvestment, innovation, and international expansion (Varblane and Varblane 2010). While internationally recognised examples of high productivity exist, particularly in the startup sector, their impact remains concentrated and has not diffused broadly throughout the economy (Martinson 2026).

A second group of observations concerns the apparent disconnect between innovation capability and aggregate productivity. Estonia is widely regarded as a successful digital state, with strong digital infrastructure and entrepreneurial activity. Nevertheless, productivity levels remain significantly below those of leading European economies (OECD 2024a, European Commission 2025). Similarly, many policy recommendations advocated by the OECD, the IMF, and European Union institutions – including investments in innovation, digitalisation, and knowledge transfer – have been implemented for years without producing the expected productivity convergence. This suggests that the challenge may lie not in the absence of policy instruments, but in the system's ability to translate and diffuse their effects across the broader economy (Caraça et al. 2009).

A third group of observations relates to the interaction between scale, capital accumulation, and adaptation. Estonia's relatively limited stock of accumulated capital increases dependence on labour productivity growth and makes the economy more sensitive to external shocks (Piketty 2014, OECD 2024a). At the same time, productivity-enhancing investments often require long time horizons before generating measurable economic returns. This creates tension between short-term political and economic pressures and the sustained investments required for innovation, organisational renewal, and structural transformation (Perez 2002, Mazzucato 2014).

A related tension emerges between societal aspirations and organisational practice. While breakthrough innovation, entrepreneurship, and technological leadership are widely valued, recent evidence suggests that managerial cultures remain predominantly operational, with limited emphasis on experimentation, strategic learning, and organisational renewal (Vadi et al. 2026). In practice, organisations are often expected to innovate without fully embracing the uncertainty, internal competition, resource reallocation, and risk of failure that innovation entails. These observations collectively point to productivity as a systemic phenomenon shaped by coordination, adaptation, and long-term capability development rather than by individual policy measures or technological investments alone.

A fourth group of observations concerns the tension between productivity and societal survival. NIS coherence must therefore be assessed against a broader

definition of system performance than productivity alone. Productivity measures reward the efficient transformation of inputs into economic outputs, yet societies also invest in capabilities that secure their long-term existence. Estonia's support for Ukraine, defence expenditure exceeding 5% of GDP, and family policies such as parental leave redirect labour, capital, and public resources away from immediately productive activities. In the short term, these choices may reduce measured productivity and economic efficiency. However, they strengthen national security, demographic sustainability, social resilience, and the state's capacity to continue developing under conditions of geopolitical uncertainty (Stiglitz et al. 2009, OECD 2024a). Productivity growth, therefore, cannot be assessed independently of the societal capabilities that enable future prosperity and survival.

5.2. Conceptual learnings for small national innovation systems

The system-level model introduced in Section 5.1 abstracts from several characteristics of innovation processes that are particularly consequential for small economies and that a successful strategy needs to take into account.

Outlook and expectations management based on economic concepts. The challenge for small open economies is how to compensate for limited scale through coordination, specialisation, and institutional adaptation (Katzenstein 1985, West 2017).

While diversity increases resilience and preserves options, the innovation literature suggests that concentration generates cumulative advantages through specialised networks, infrastructures, talent pools, and learning effects (Foray 2014, Jacobides et al. 2018). The challenge is therefore not choosing between diversity and concentration, but balancing them. Excessive fragmentation prevents critical mass, while excessive concentration risks lock-in and fragility, a dynamic resembling the Seneca effect (Bardi 2017).

The reviewed literature suggests four implications for policymakers. First, innovation investments rarely translate directly into economic outcomes. Significant delays often exist between investment and measurable productivity gains, with major technological transitions frequently requiring 10–15 years or more to generate broad economic effects (Perez 2002, Mazzucato 2014).

Second, innovation generation and innovation diffusion are distinct challenges. Successful innovations must repeatedly pass through development, production, adoption, and diffusion stages, requiring multiple rounds of knowledge transfer among research organisations, firms, users, supply chains, and institutions.

Third, innovation outcomes are inherently uneven. Ecosystem spillovers, scale effects, and network externalities amplify the success of a limited number of actors, while most experiments fail to scale. Consequently, productivity gains emerge through concentrated successes rather than uniform improvements across the economy.

Fourth, productivity growth depends on institutional continuity. Innovation systems require transparent institutions, predictable rules, trust, and cooperation over extended periods. Consequently, the role of policy extends beyond supporting

innovation generation to sustaining the conditions that allow innovations to diffuse throughout the economy and ultimately contribute to long-term productivity growth, resilience, and well-being.

The Estonian case, examined in the following section, illustrates how these characteristics interact in a specific configuration and where the resulting coherence failures concentrate.

5.3. Estonia's digital state paradox and system incoherence

Digital state paradox. Estonia's case is particularly revealing because it combines elements of all three failure modes noted in Section 3: FDI and foreign-owned innovation that does not diffuse, concentrated innovative actors that do not connect to the mainstream economy, and niche-specific digital infrastructure that does not translate into private-sector productivity, all within a single national system.

Estonia's e-government model is among the most thoroughly documented cases of state-led digital transformation in the scholarly literature (Kattel and Mergel 2019). Yet digital public services have not been absorbed into private-sector productivity at a comparable rate: OECD (2024) data show that AI and digitalisation have penetrated approximately 10–15% of firms outside the technology sector, while the majority of manufacturing, construction, logistics, and services firms continue to operate without systematic digital transformation (European Commission 2025, Vadi et al. 2026). The translation gap between a publicly available digital infrastructure and its uptake by private actors is what drives Estonia's digital state paradox.

This gap is not primarily technological, as Estonia's population has high digital literacy, and the technical infrastructure is accessible. Vadi et al.'s (2026) study of Estonian management practices offers a clue: firms with higher value added make decisions based on future needs rather than present constraints, apply more decentralised decision-making structures, and integrate technology strategically rather than adopting it as a cost item. The majority of SMEs, by contrast, operate in what the study characterises as a reactive mode: they neither perceive the need for change nor know how to achieve it. The result is that nearly 40% of workers are overqualified or underqualified for their positions (OECD 2024b) – not a skills problem in the conventional sense, but a management problem: the organisational structures needed to deploy available human and technological capital productively are absent.

Startup concentration and the diffusion problem. Estonia's startup ecosystem is, by any per-capita measure, a global outlier. With approximately 17,000 startup employees contributing 4.5–5.5% of GDP, and with sales per employee in the startup sector exceeding the Estonian and EU averages by several times, the sector demonstrates that very high productivity is achievable in Estonia's economic context (Martinson 2026). This is the high ceiling: a small cohort of highly innovative firms operating at the global productivity frontiers.

The problem is that innovation-economy outcomes follow a power-law rather than a normal distribution logic: a small number of firms create the majority of value, while most attempts do not reach scale. This is not unique to Estonia; it

characterises innovation ecosystems globally. What is distinctive about Estonia is the structural disconnection between this high-performing cohort and the majority of the economy. The startup sector's knowledge, networks, and productivity approaches do not diffuse to incumbent SMEs, traditional manufacturing, or the construction and logistics sectors, which together account for a substantial share of employment. The European Commission (2020) documents that the concentration is partly a function of policy design: the Startup Estonia programme and associated instruments are calibrated to support startup formation and growth, not to build absorptive capacity in the incumbent economy.

The TRL 4–7 gap: where coherence breaks down. A third mechanism is the valley of death at technology readiness levels (TRL) 4–7 (Mankins 1995, 2009), between laboratory proof-of-concept and first commercial application. Estonia has genuine research capacity, particularly in information and communications technology, materials, and life sciences, and a culture of startup formation that can generate early-stage ventures. What is systematically weak is the institutional infrastructure connecting these two: translational platforms, pilot facilities, first-customer mechanisms, and bridge financing instruments that would allow research outputs to become commercial products (Håkansson and Waluszewski 2002, 2018). The knowledge does not move from the university to the firm, not because the actors are absent or unwilling, but because the institutional scaffolding that Torres de Oliveira et al. (2022) identify as a precondition for productive cooperation is insufficiently developed.

Estonian firms also lack the capacity to formulate clear R&D demand. The bottleneck is on both the supply side (insufficient translational platforms) and the demand side – firms operating in a reactive management mode do not generate the kind of specific, actionable research questions that would allow universities and public research institutions to orient their work towards commercially relevant problems. This is institutional incoherence at its most micro-level: two sets of actors with potentially complementary resources – research capacity and market proximity – separated by a failure of the interaction rules that would make collaboration productive.

Mapped onto the framework axes, Estonia presents a distinctive configuration: moderate-to-high institutional implementation capacity in specific domains (digital infrastructure, startup policy) combined with structurally low collaborative capacity across the broader economy. The result is a system with a high ceiling and a low floor – precisely the condition the scenario analysis in the following sections is designed to explore.

5.4. From conceptual synthesis to scenario design

Identification of critical system dimensions. The preceding literature review and empirical observations suggest that Estonia's productivity challenge is shaped less by the availability of resources than by the ability to coordinate, adapt, and translate resources into value creation. The literature highlights recurring themes of innovation diffusion, ecosystem formation, institutional continuity, adoption dynamics,

and long-term capability development. Similarly, the section on observations identified tensions related to innovation translation, managerial adaptation, capital accumulation, and the diffusion of productivity gains beyond a limited number of high-performing actors.

The purpose of the scenario design phase is therefore to identify the critical uncertainties that may lead to qualitatively different productivity trajectories in the future. Following the intuitive logics tradition of scenario development, candidate dimensions were evaluated against three criteria: (1) high influence on long-term productivity growth, (2) high uncertainty regarding future development, and (3) relative independence from one another.

A broad range of potential dimensions was considered, including technological development, digitalisation, demographics, geopolitical conditions, innovation intensity, human capital, energy transition, collaboration, and institutional performance. While many of these factors significantly influence productivity, several were found to be either consequences of deeper systemic mechanisms or strongly interdependent. The two axes synthesise several underlying factors and reflect the ability to initiate and execute change: (1) collaborative capacity describes bottom-up and cultural aspects such as the ability of firms, research organisations, investors, public institutions, and citizens to exchange knowledge, coordinate actions, pursue shared objectives, and self-police social and moral norms; and (2) institutional implementation capacity describes the top-down ability of institutions to establish legitimate and predictable rules, coordinate collective action, protect long-term societal interests, and adapt governance arrangements to changing circumstances (Wieczorek and Hekkert 2012). In this sense, institutions do not merely constrain behaviour but actively shape the environments within which decisions are made and collective outcomes emerge.

Institutional implementation capacity also contributes to the creation of generalised trust – the expectation that individuals, organisations, and public authorities will behave in a fair, predictable, and cooperative manner (Rothstein and Uslaner 2005). More broadly, institutional implementation capacity determines the extent to which societies can formulate, implement, and sustain collective rules and long-term investment strategies, thereby enabling resources to be mobilised towards shared productivity objectives (Acemoglu et al. 2005). In the context of productivity growth, institutional implementation capacity determines whether resources can be mobilised towards shared objectives and sustained over time, with future generations in mind.

Construction of the scenario space. The two dimensions identified above can be understood as system-level resources that determine how effectively a society converts knowledge, capital, technology, and human capabilities into productivity growth. Unlike external conditions such as geopolitical developments, technological disruptions, demographic change, or energy transitions, these dimensions are largely endogenous.

Both dimensions may vary independently between fragmented and coherent states. Collaborative capacity ranges from isolated actors and weak knowledge

exchange to coordinated ecosystems characterised by trust, learning, and shared objectives. Institutional implementation capacity ranges from reactive and fragmented governance to effective execution, strategic continuity, and the ability to coordinate collective action over extended periods. Together, they describe the system's capacity to mobilise resources, adapt to shocks, and sustain long-term development.

Following the intuitive logics tradition of scenario planning, the purpose of the scenario framework is not to predict the future, but to explore a set of internally coherent development paths that emerge from different combinations of critical uncertainties (Schwartz 1997, van der Heijden 2005). The intersection of collaborative capacity and institutional implementation capacity produces four qualitatively different system configurations. These configurations represent alternative trajectories through which innovation, technology diffusion, labour mobility, investment behaviour, and productivity growth evolve over time.

While all scenarios are exposed to the same external environment, they differ fundamentally in their ability to respond, adapt, and transform available resources into long-term productivity growth and societal well-being. Building on the operationalised productivity framework and the preceding conceptual analysis, each scenario is examined through the interaction of institutions, collaboration, innovation, technology diffusion, labour mobility, and investment dynamics.

5.5. The four scenarios as analytical positions

The intersection of the two axes generates four analytically distinct system configurations, each representing a qualitatively different logic of NIS functioning (Figure 1). The four configurations are described here as analytical types; their application to Estonia's current position and possible future trajectories follows in Section 5.8.

5.6. Stress testing and feedback mechanisms

To evaluate the robustness of the four productivity configurations, the scenario framework was stress-tested against 26 internal and external shocks (Appendix 1).

The internal shocks include radical policy choices, institutional dysfunctions, and societal interventions that originate from within Estonia. Examples range from AI-enabled public-sector transformation and strategic industrial concentration to risk-avoidant governance, universal basic income, talent repatriation, and new approaches to social welfare. The external shocks include technological breakthroughs, geopolitical fragmentation, demographic pressures, climate and energy disruptions, financial instability, migration, and changes in global digital infrastructures.

With the system's starting point placed at a neutral reference point, the analysis examined which scenario (system configuration) each shock would push the economy and society towards, who would gain and lose most from the change, how to correct the course towards the desired path, and which actors would be responsible for the correction.

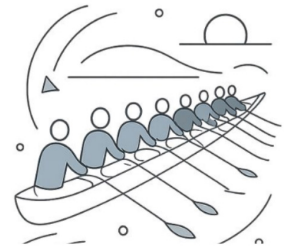
low ← collaborative capacity → high

Village



A vibrant but unscalable system: civil society, firms, and research institutions engage actively; innovation culture is strong; networks and pilot solutions proliferate. The state cannot provide the strategic framework or market-creation capacity that would convert this energy into economy-wide structural change. Young people and talented workers are active but insecure; incomes are unstable; inequality grows even as creativity thrives. The 2035 projection is approximately 80–85% of the EU average.

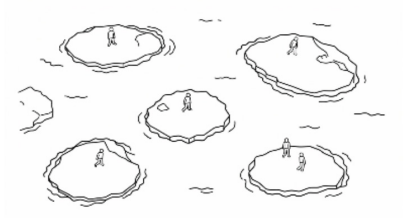
Synchronised Estonia



The only configuration in which the productivity target of 110% of the EU average by 2035 is achievable. The state establishes clear priorities, creates markets, and functions as an innovation catalyst, rather than waiting for the market to find solutions, actively shaping the conditions for private-sector development to occur. Firms and research institutions operate in an integrated ecosystem; cooperation is systemic. AI and digitalisation diffuse broadly across the economy. The system can absorb shocks and adjust trajectories.

low ← institutional implementation capacity → high

Every man is an island



Policy remains reactive and fragmented: programmes emerge in parallel without systemic connection, and the state is unable to function as a market shaper or innovation accelerator. Firms and research institutions optimise within their own domains; the most capable individuals and organisations connect to international networks rather than contributing to domestic system development. The 2035 projection is approximately 70% of the EU average productivity.

Low ceiling



A bureaucratically effective but dynamically constrained system: institutions function and reforms are implemented, but the state lacks the vision and the actor network to create new markets or push the economy towards higher value-added activities. Firms focus on efficiency and risk reduction rather than innovation. The system reaches a plateau, unable to generate the structural transformation needed for sustained productivity convergence. The 2035 projection is approximately 85–90% of the EU average: stability without ambition.

Figure 1. The four configurations on the collaborative capacity and institutional implementation capacity axes.

Taken together, the shocks serve as probes that reveal the strengths and weaknesses of different system configurations. Rather than focusing on the probability of individual events, the analysis examines how different configurations (Figure 1) influence the system's ability to absorb disturbances, adapt to changing conditions, and sustain long-term productivity growth. The purpose of stress testing is therefore not to predict future crises, but to identify vulnerabilities, recovery mechanisms, and strategic capabilities required for resilience in a turbulent environment.

Feedback-to-shock pattern analysis provides an interactive tool for engaging decision-makers. The list of shocks can be edited interactively, and the shock analysis can be conducted through various team exercises.

A collective analysis of the 26 shocks is presented in Appendix 2. The internal and external shocks are not distributed evenly across the scenario space. Instead, they reveal structural biases, vulnerabilities, and recovery mechanisms embedded in the system.

First, the shock set is not neutral. Most shocks place downward pressure on either collaborative capacity or institutional implementation capacity, reflecting the reality that coordination and institutional quality are difficult to build but relatively easy to erode. Several shocks directly increase fragmentation, uncertainty, or resource competition, while comparatively few automatically strengthen cooperation or governance capacity. This implies that maintaining a high-performing trajectory requires continuous effort, whereas drift towards lower-performing trajectories can occur through inertia alone.

Second, the shocks cluster unevenly across the scenario space. Many external shocks tend to push the system towards the 'Every man is an island' trajectory by reducing trust, increasing uncertainty, and weakening long-term coordination. A smaller group of shocks, particularly those associated with artificial intelligence, digitalisation, startup growth, strategic investment, and talent attraction, create opportunities to move towards 'Synchronised Estonia', provided sufficient institutional and collaborative capabilities already exist. Few shocks naturally reinforce the intermediate scenarios. Instead, 'Low ceiling' and 'Village' often emerge as transitional states between fragmentation and synchronisation.

Third, the distribution of impacts is highly uneven. The groups most vulnerable across scenarios are workers in routine occupations, regions dependent on declining industries, younger generations entering the labour market, and individuals who rely on strong public services. These groups are disproportionately affected when collaboration weakens or institutions lose the capacity to coordinate adaptation. Conversely, the principal beneficiaries of positive shocks are highly skilled workers, entrepreneurs, globally connected firms, researchers, and investors capable of rapidly exploiting new opportunities. Without effective diffusion mechanisms, productivity gains therefore risk concentrating within a limited number of sectors, firms, and individuals.

Fourth, the recovery patterns are remarkably consistent across shocks. Successful recovery rarely depends solely on additional financial resources. Instead, recovery mechanisms repeatedly involve rebuilding trust, restoring coordination between

actors, strengthening institutional execution, accelerating knowledge diffusion, and improving the translation of innovation into economic activity. This finding aligns with the literature review, which identified innovation diffusion and ecosystem coordination as critical determinants of productivity growth.

Finally, the burden of recovery is not distributed evenly. While governments play an essential role in establishing rules, reducing uncertainty, and coordinating collective action, the actual recovery effort is shared across the innovation system. Firms undertake technological adaptation and investment, research institutions generate and transfer knowledge, investors provide risk capital, and citizens contribute through skills development, labour mobility, and participation in collaborative networks. The strongest recovery trajectories emerge when these actors operate as a coordinated system rather than as isolated entities.

Of the 26 shocks, roughly two-thirds are fundamentally tests of institutional implementation capacity, while only a minority primarily test technological capability.

5.7. Stress testing of scenario trajectories

The focus then shifted from the individual shock-feedback level to system-level analysis. The resilience of the four scenario configurations became the subject of individual testing. The driving questions were: how well can different configurations handle the shocks? How many shocks can be managed in a way that benefits society under each configuration: 'Every man is an island', 'Low ceiling', 'Village', or 'Synchronised Estonia'?

To ensure comparability, each shock was reformulated as a societal challenge or opportunity requiring a response rather than as a predetermined positive or negative event (Appendix 3). The analysis builds on resilience theory (Holling 1973, Walker et al. 2004), which views societies as adaptive systems exposed to disturbances, disruptions, and structural change.

Following Walker et al. (2004), the shocks were sorted into three categories that required different reactions from the economy and society. Resilience is the ability to maintain core functions amid disruption. Adaptability refers to the ability to reorganise resources, institutions, and behaviours while remaining on the same development trajectory. Transformability refers to the ability to create a superior trajectory when existing arrangements become inadequate. For each challenge, the response of each scenario was assessed on a three-level scale (improvement, no change, decline). The resulting patterns were then aggregated to identify the relative strengths, vulnerabilities, recovery potential, and critical dependencies of each scenario configuration type.

Table 1 summarises the number of shocks that were resolved positively across the three challenge categories in each scenario. (If the situation derived from the shock description was not possible in a given scenario, the total number of opportunities was reduced.)

Table 1. Positive challenge-resolution outcomes across resilience, adaptability, and transformability challenge categories

Configuration	Resilience challenges (n = 10)	Adaptability challenges (n = 9)	Transformability challenges (n = 7)	Critical dependency
C1 Every man is an island	0/10	2/9	0/7	Trust and institutional rebuilding
C2 Low ceiling	2/8	4/8	5/6	Collaboration and ecosystem spillovers
C3 Village	2/5	7/9	4/7	Scaling and implementation capacity
C4 Synchronised Estonia	8/8	8/9	7/7	Long-term institutional continuity

The stress tests reveal a clear division of strengths. Configuration C1 ('Every man is an island') performs poorly across all challenge categories, indicating that fragmentation simultaneously undermines resilience, adaptation, and transformation. Configuration C2 ('Low ceiling') demonstrates limited resilience and moderate adaptability but performs relatively well when challenges can be addressed through institutional intervention and top-down coordination, enabling transformation. Configuration C3 ('Village') exhibits strong adaptive capacity and above-average transformability, reflecting the strength of bottom-up initiatives and social mobilisation. However, its weak performance on resilience challenges suggests that cooperation alone cannot compensate for limited implementation capacity when society faces systemic disruptions.

Configuration C4 ('Synchronised Estonia') is the only scenario that performs consistently well across all three dimensions. The combination of collaborative capacity and institutional implementation capacity allows the system to absorb shocks, adapt to changing circumstances, and implement structural transformations when necessary. Its few weaknesses occur in challenges involving severe societal fragmentation, where communication and coordination mechanisms themselves become impaired.

Taken together, the results support the central proposition of this study: neither institutional implementation capacity nor collaborative capacity alone is sufficient to sustain productivity growth under uncertainty. Small open economies require both. The ability to combine top-down coordination with bottom-up cooperation emerges as the key determinant of resilience, adaptability, and long-term development.

5.8. Estonia's current position and the mechanisms of incoherence

Estonia's current NIS configuration does not fit neatly into any single quadrant. Its institutional infrastructure, particularly the digital state, the startup policy ecosystem, and the research funding framework, demonstrates elements of implementation

capacity. Its startup sector and the density of its technology community demonstrate elements of collaborative capacity within that specific actor group. However, at the level of the broader economy, the system exhibits the characteristic patterns of configurations C1 and C2: fragmented policy instruments that do not constitute a coherent strategic framework, cooperative relationships that are strong within the innovative elite but weak between that elite and the majority of firms, and digital infrastructure whose productivity potential has not been absorbed by the private sector.

The three mechanisms driving this position (the translation gap, startup concentration, and the TRL 4–7 gap) are examined in detail in Section 5.3. Their combined effect is to place Estonia in the lower half of the coherence space: moderate implementation capacity in specific domains, but structurally low collaborative capacity across the broader economy.

5.9. The role of the state across configurations

In the 'Village' configuration, the state acts as a facilitator of experimentation and community initiatives. Cooperation is strong, but the absence of implementation capacity limits the scaling of successful initiatives and reduces resilience to systemic shocks. Only in the 'Synchronised Estonia' configuration does the state function as an architect and orchestrator, aligning actors, incentives, and institutions around shared long-term objectives.

The stress-testing results demonstrate that these differences extend beyond innovation policy. The same configuration that determines the effectiveness of R&D support, startup policies, or digitalisation programmes also determines the system's capacity for resilience, adaptation, and transformation. Top-down capability alone can sustain stability and implement targeted reforms, while bottom-up cooperation alone can generate experimentation and adaptation. However, neither is sufficient to address the full range of societal challenges. The highest performance consistently emerges when institutional implementation capacity and collaborative capacity reinforce one another.

The significance of this finding is that the effectiveness of a policy instrument depends less on its design than on the system configuration in which it operates. Investment in translational infrastructure, digital platforms, or innovation support generates broad productivity gains only when firms, institutions, and citizens possess the capabilities required to absorb and diffuse their effects. What distinguishes the 'Synchronised Estonia' configuration from the others is precisely that its institutional architecture creates and sustains these complementarities. In the other configurations, the complementarities remain absent – not because the instruments are wrong, but because the system conditions for their effectiveness do not exist.

6. Discussion

6.1. What small states can and cannot do

The relevant literature and the Estonian scenario framework together generate a set of propositions about the conditions under which small-state NIS configurations can and cannot produce economy-wide productivity gains. These propositions are not universal laws but conditional generalisations whose validity depends on the specific structural features of small open economies. Yet they are sufficiently robust across the cases examined to constitute a theoretical contribution to the literature on NIS and productivity in small open economies, rather than simply observations about Estonia.

First, small states cannot sustain broad technological diversification across all trajectories and should not attempt to. Lee et al.'s (2021) cycle-time typology demonstrates that successful catching-up requires either deliberate specialisation into short-cycle-time sectors or sustained investment in knowledge localisation and diversification within a defined technological base. The Irish, Singaporean, and Icelandic cases all illustrate the consequences of partial commitment to one or the other: each has achieved high performance within its chosen model while encountering structural ceilings in the transition to the next stage. Estonia's configuration adds a fourth variant: an innovation system characterised by world-class digital infrastructure and entrepreneurial capability whose productivity effects remain weakly diffused across the wider economy.

Second, the 'rising tide' logic, in which innovation-driven growth in leading sectors diffuses to raise the productivity floor for the broader economy, operates only when the system is coherent. A high ceiling is not sufficient; what is required is an institutional architecture that connects the ceiling to the floor: translational infrastructure, the development of management quality, cooperative networks that bridge the innovative elite and the mainstream economy, and a state capable of maintaining strategic direction across political cycles. Where these conditions are absent, innovation activity concentrates rather than diffuses, and the resulting aggregate productivity statistics reflect a small number of frontier firms rather than economy-wide development. This suggests that innovation generation and innovation diffusion should be treated as analytically distinct processes within NISs.

Third, the specific form of coherence that small states need differs from that required by large economies. Large NISs can sustain significant incoherence between subsystems because the scale of each subsystem is sufficient to generate its own internal momentum. Small NISs lack this buffer: the overall system cannot reach critical mass in any of the subsystems. The Nordic model's integration of innovation policy with educational, social, and labour market policies, documented by Casadella and Tahi (2025) for Sweden and Finland, is not a cultural preference but a structural necessity: small states cannot afford the coordination costs of treating these as separate policy domains.

More broadly, these findings resonate with Acemoglu and Robinson's (2019) argument that sustained prosperity depends on the co-evolution of capable institutions

and capable societies. While their 'narrow corridor' is developed in the context of political institutions and liberty, the present study operationalises a comparable logic for NISs. Institutional implementation capacity and collaborative capacity are treated as complementary productive resources whose interaction determines whether innovation is translated into economy-wide productivity growth. From this perspective, system coherence is not merely a desirable characteristic of an innovation system but a productive capability in its own right.

6.2. Policy implications

The framework generates policy implications that are both specific to Estonia and applicable to comparable small open economies characterised by limited scale, external dependence, and innovation-driven development. Three are of particular significance.

The first concerns the sequencing of interventions. The scenario analysis demonstrates that investment in frontier innovation support (startup ecosystems, deep-technology research, FDI attraction) produces different outcomes for country-level productivity depending on whether the absorptive capacity of the broader economy is being developed in parallel. Without investment in management quality, translational infrastructure, and the institutional scaffolding for knowledge diffusion, frontier investments raise the ceiling without affecting the floor. The findings therefore suggest that innovation policy should be evaluated both by its ability to generate frontier innovations and by its capacity to diffuse them throughout the wider economy.

The second concerns the state's institutional identity. The scenario framework demonstrates that the difference between the 'Synchronised Estonia' configuration and the others is not primarily a matter of specific policies but of the state's role in the innovation system. A citizen who understands their active contribution, together with a state that understands itself as a market shaper actively creating the conditions for private sector development through procurement, standards, data access, and translational investment, generates qualitatively different system dynamics from those of a system in which the state understands itself as a regulator and service provider. Mazzucato's (2014) entrepreneurial state concept captures this distinction, but the scenario framework grounds it in the specific institutional mechanisms through which it operates in a small-state context.

The third concerns the interaction between institutions and society. The results indicate that institutional implementation capacity and collaborative capacity should not be interpreted as substitutes. Strong institutions cannot compensate indefinitely for weak cooperation, just as strong societal initiative cannot overcome persistent implementation failures. The highest-performing configuration consistently emerges when both capacities reinforce one another. This finding aligns with institutional theories that emphasise the joint evolution of capable states and capable societies (Acemoglu and Robinson 2019), while extending them to explain productivity dynamics within NISs.

More generally, the framework suggests that productivity policy should be understood as the design of coherent sociotechnical systems rather than the optimisation of individual policy instruments. Investments in digitalisation, research, entrepreneurship, education, or translational infrastructure generate their greatest impact when embedded within institutional arrangements that promote coordination, trust, and long-term implementation. From this perspective, the effectiveness of innovation policy depends less on the number of interventions than on the coherence of their interactions.

6.3. Limitations

The analysis presented in this paper is subject to several limitations that circumscribe the generalisability of its conclusions. First, the scenario methodology produces qualitative analytical positions rather than quantitative trajectory estimates. While the framework identifies alternative system configurations and their relative strengths and vulnerabilities, it does not specify the magnitude of the interventions required to shift between configurations, or the threshold conditions under which such transitions would occur. It explains directional tendencies and comparative outcomes rather than predicting precise developmental paths. This limitation is inherent in scenario analysis under conditions of deep uncertainty, and consequently the policy implications should be interpreted as strategic rather than prescriptive.

Second, the comparative case analysis is necessarily selective. Ireland, Singapore, and Iceland were chosen to illuminate specific aspects of the coherence problem, not to constitute a representative sample of small-state NIS configurations. Denmark, Finland, and the other Nordic cases – present in the studies of Edquist and Hommen (2008) and Casadella and Tahi (2025) – might generate somewhat different conclusions about the conditions for high coherence, particularly regarding the role of corporatist institutions and labour market flexibility. The framework should be tested against a broader comparative base in future research.

Third, the axes themselves are theoretically derived rather than empirically validated. The framework positions NISs qualitatively along two dimensions without a measurement instrument for either. Operationalising these axes through composite indices, drawing on existing data sources such as the European Innovation Scoreboard, Worldwide Governance Indicators, or OECD innovation policy surveys, would allow the framework to be applied systematically across a broader sample of small states and tested against quantitative productivity outcomes. This represents the most significant avenue for future research, and the one most likely to determine whether the coherence framework constitutes a replicable analytical tool or remains a theoretically productive but case-specific contribution.

7. Conclusion

This paper has argued that the Estonian productivity paradox – strong innovation indicators combined with persistently below-average economy-wide productivity – is best understood as a problem of NIS coherence rather than a shortage of innovation resources. Drawing on NIS theory, institutional economics, systems thinking, and scenario analysis, the study demonstrates that strong digital infrastructure, entrepreneurial activity, and research capability remain insufficient unless they are effectively translated into productivity gains throughout the wider economy.

The principal contribution of this study is the operationalisation of NIS coherence through two interacting dimensions: institutional implementation capacity and collaborative capacity. The analysis suggests that productivity in small open economies is better understood as an emergent property of coherent sociotechnical systems than as the cumulative outcome of individual innovation policies. Strong institutions, frontier firms, digital infrastructure, or research excellence are individually insufficient if they remain weakly connected. What differentiates successful productivity trajectories is the capacity of institutions and society to coordinate, diffuse, and sustain innovation over time.

Methodologically, the study extends the intuitive logics tradition of scenario planning by integrating systems thinking, design science, resilience theory, and structured stress testing into a feedbacked shock-sensitive scenario framework. Rather than treating scenarios as static narratives, the framework models alternative productivity trajectories as adaptive sociotechnical systems capable of responding to endogenous and exogenous shocks.

Although developed using the Estonian case, the framework is intended to be transferable to other small open economies facing similar challenges of innovation diffusion, institutional coordination, and external vulnerability. Future research should operationalise the proposed coherence dimensions quantitatively and evaluate their explanatory power across broader comparative settings. More generally, the study suggests that productivity should be understood not simply as the outcome of technological progress or innovation intensity, but as an emergent property of coherent sociotechnical systems capable of translating knowledge into economy-wide value under conditions of uncertainty.

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Declaration of the use of AI-assisted technologies in the writing process

During the preparation of this work, the authors used OpenAI's ChatGPT-5 (academic version) and Anthropic's Claude as academic writing assistants for searching literature, editing language, and enhancing clarity. The scenario matrix illustrations were created using Gamma.app. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Data

Desk research data used to develop the scenario axes are described in Section 4.3. Data used for shock-resistance and feedback analysis, along with scenario testing, are presented in the Appendices.

Appendix 1. Shortened shock descriptions

Appendix 2. Scenario analysis according to the feedback framework

Appendix 3. Generalised challenge set for scenario stress testing

Appendices are available at https://doi.org/10.3176/tr.2026.2.S102 as supplementary online material.

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