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THE INSTITUTIONAL MECHANISM FOR THE INNOVATIVE DEVELOPMENT OF THE RAILWAY NETWORK

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Abstract: This article develops an institutional mechanism for the innovative development of the railway network, with a focus on state policy. The purpose is to substantiate a governance structure that enables rather than obstructs innovation. The study identifies the core institutional problem as a regulatory gap: technology advances exponentially while regulation adapts slowly, so that safety-enhancing innovations wait, stall, or leave the sector. Drawing on recent reforms — the creation of a single directing body for the railway, adaptive performance-based regulation, and dedicated innovation gateways integrating startups and research — a three-level mechanism is proposed, linking long-term strategy, institutional design, and delivery.

Keywords: institutional mechanism, state policy, railway regulation, directing mind, regulatory gap, adaptive regulation, innovation governance.

Annotatsiya: Maqolada temir yo'l tarmog'ini innovatsion rivojlantirishning institutsional mexanizmi davlat siyosatiga urg'u bilan ishlab chiqilgan. Maqsad — innovatsiyaga to'sqinlik qilmaydigan, aksincha, unga imkon beruvchi boshqaruv tuzilmasini asoslashdan iborat. Tadqiqot asosiy institutsional muammoni tartibga solish tafovuti sifatida aniqlaydi: texnologiya eksponensial rivojlanadi, tartibga solish esa sekin moslashadi, natijada xavfsizlikni oshiruvchi innovatsiyalar kutadi, to'xtaydi yoki sohadan chiqib ketadi. So'nggi islohotlar asosida uch darajali mexanizm taklif etildi: uzoq muddatli strategiya, institutsional dizayn va ijro o'zaro bog'landi.

Kalit so'zlar: institutsional mexanizm, davlat siyosati, temir yo'l tartibga solish, yagona boshqaruv, tartibga solish tafovuti, moslashuvchan tartibga solish, innovatsiya boshqaruvi.

Аннотация: В статье разработан институциональный механизм инновационного развития железнодорожной сети с акцентом на государственную политику. Цель — обоснование структуры управления, которая способствует инновациям, а не препятствует им. Основная институциональная проблема определена как «регуляторный разрыв»: технологии развиваются экспоненциально, а регулирование адаптируется медленно, из-за чего инновации ждут, замирают или покидают отрасль. На основе современных реформ предложен трёхуровневый механизм, связывающий долгосрочную стратегию, институциональный дизайн и реализацию. Научная новизна — переосмысление институциональной реформы вокруг закрытия регуляторного разрыва, а не только реструктуризации собственности.

Ключевые слова: институциональный механизм, государственная политика, регулирование железных дорог, единое управление, регуляторный разрыв, адаптивное регулирование.

INTRODUCTION

Technology and the rules that govern it rarely move at the same speed. In the railway sector this mismatch has become acute: sensors, predictive analytics, and automated systems evolve from year to year, while the frameworks that approve them were often written for an age of static data and analogue inspection. The result is a paradox — a sector rich in available innovation yet slow to adopt it, held back not by a shortage of ideas but by the institutions meant to admit them. Closing this gap is the central concern of this article.

The nature of the problem is increasingly recognised in policy debate. Industry voices argue that the core challenge is not regulatory burden but regulatory alignment¹: rules rooted in safety but crafted in a different technological era too often delay or deny safety-enhancing technologies without clear justification, and what is needed is a regulatory system that matches the speed of innovation through an adaptive, performance-based approach grounded in data rather than prescriptive mandates [1]. The institutional question, in other words, is not whether to regulate but how to regulate at the pace of change.

¹ Regulatory alignment (as distinct from regulatory burden) — the degree to which the rules governing a sector keep pace with, and are structured to admit, technological change; misalignment occurs when rules designed for an earlier technological era delay or block newer, proven solutions.

Structural reforms under way in several countries illustrate the search for an answer. One major reform establishes a single public body to bring together infrastructure, system operation, and passenger services as the sector's «directing mind,» accompanied by a new thirty-year strategy and five-year business plans intended to strengthen collaboration, unlock efficiencies, and incentivise innovation [2]. Elsewhere, a national railway has launched a technology policy creating a structured framework to integrate startups, innovators, research institutions, and industry partners, with a single digital portal replacing rigid vendor-selection mechanisms to move solutions swiftly from concept to deployment [3]. The task of this article is to distil such reforms into a coherent institutional mechanism for innovative development.

The purpose of the study is to develop an institutional mechanism for the innovative development of the railway network. Its objectives are to identify the core institutional obstacle to innovation; to substantiate the components of the mechanism; to link them across strategy, design, and delivery; and to outline conditions for adapting the mechanism to a national context.

REVIEW OF LITERATURE ON THE SUBJECT

The institutional framework of a railway system — the policies on public funding, the mix of public and private roles, and the role of regulation — sits above the technical network and shapes the pattern of technologies and services it produces; this framework is never fixed, evolving as technologies advance and governments shift [4]. This foundational view establishes that innovation outcomes are not determined by technology alone but by the institutional environment that admits or resists it.

A recurring theme in reform literature is fragmentation². Analyses of railway systems have identified a lack of innovation alongside fragmentation, government micromanagement, declining productivity, and a weakening financial position as intertwined institutional failings [5]. The proposed remedy — a single directing body — aims to strip back the fragmentation created by earlier franchising arrangements; yet commentators caution that the commercial effect on innovation depends less on structure itself than on how the new body exercises its powers, in particular whether centralisation alters the incentives to invest, innovate, and price risk efficiently [6]. Structure, in short, is necessary but not sufficient.

A third strand addresses the design of innovation-friendly regulation directly. Studies of technology-induction frameworks show a shift away from complex vendor selection based on rigid specifications toward simplified, innovation-driven processes focused on the trial and adoption of new technologies, explicitly drawing on best practice from defence-innovation initiatives and startup ecosystems [3]. In parallel, regulators themselves are being reformed to reduce administrative burden and to monitor whole-system delivery rather than to police prescriptive rules [7]. What the literature has not yet consolidated is a single mechanism that connects strategy, structure, and adaptive regulation around the explicit goal of closing the gap between the pace of technology and the pace of its institutional admission — the contribution this article makes.

RESEARCH METHODOLOGY

The mechanism is built by first diagnosing the institutional problem precisely, then designing components that address its root rather than its symptoms. The diagnosis proceeds by contrasting the trajectory of technological capability with that of regulatory adaptation, locating the gap between them. The design then derives, from documented reforms, the institutional components that narrow this gap, organised by the function each performs across three levels: strategy, institutional design, and delivery.

The analysis draws on institutional analyses of railway reform [4; 5], structural reform proposals [2; 6], innovation-policy frameworks [3], and regulatory-reform practice [1; 7]. Cases were chosen for having explicit institutional structures and stated innovation objectives. The components are classified by their role in the mechanism rather than by their national origin, so that the model is transferable in principle; national adaptation, however, requires attention to the local balance of public and private roles, which the study treats as a boundary condition rather than a fixed parameter.

ANALYSIS AND RESULTS

The diagnosis is captured in Figure 1, which contrasts the two trajectories at the heart of the problem. Technological capability rises steeply, almost exponentially, as digital tools compound one another; regulatory permissiveness rises slowly and roughly linearly, constrained by deliberative and safety-driven processes. The widening space between the curves is the regulatory gap — the zone where a proven, safe technology exists

2 Fragmentation — in railway governance, the division of responsibility for infrastructure, operations, and services among many separate bodies, which can raise coordination costs and weaken the incentive and ability to innovate across the whole system.

but has not yet been institutionally admitted, and where innovations wait, stall, or exit the sector (Figure 1).

Figure 2. The regulatory gap: technology outpaces regulation, creating the core institutional problem

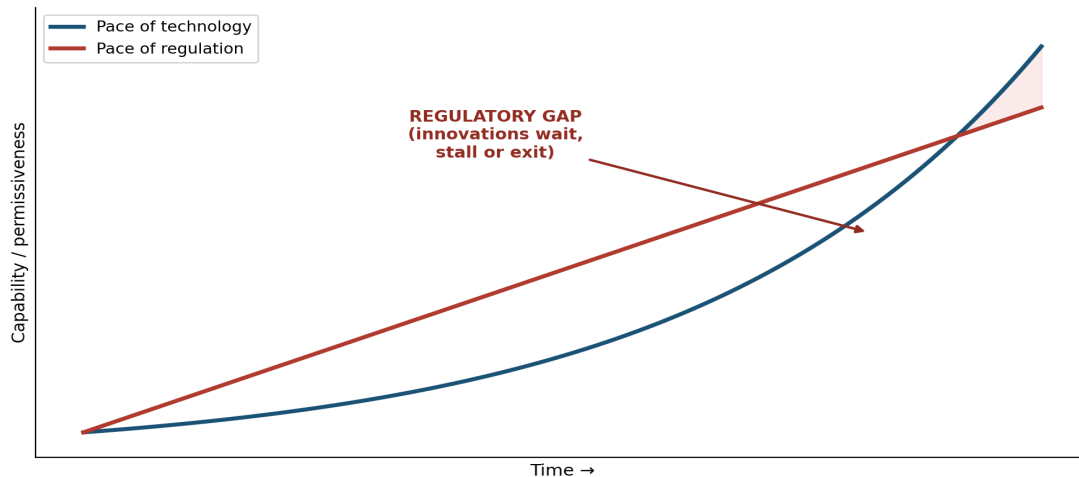


Figure 1. The regulatory gap between technology and regulation³

The mechanism designed to close this gap operates on three levels, shown in Figure 2. A strategy level sets long-term direction and ties it to multi-year plans that reward innovation; an institutional-design level combines three pillars — a directing mind to overcome fragmentation, adaptive regulation to match the pace of technology, and an innovation gateway to admit external ideas; and a delivery level converts these into reduced fragmentation, faster adoption, and investor confidence, with feedback adjusting policy as performance is observed (Figure 2).

Figure 1. Institutional mechanism for innovative rail development (author's development)

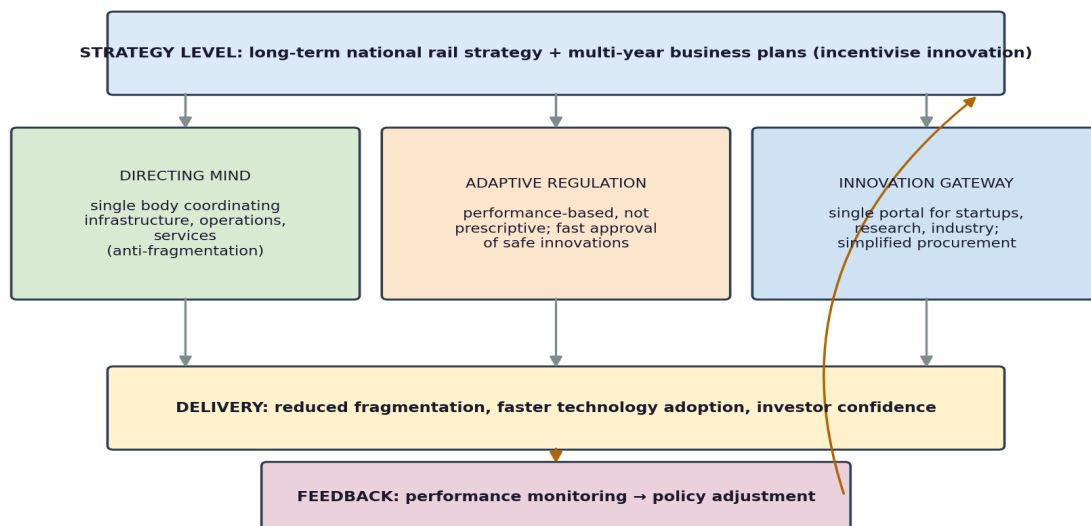


Figure 2. Three-level institutional mechanism for innovative rail development⁴

The three institutional pillars, each addressing a distinct facet of the problem, are set out in Table 1. Their complementarity is the point: a directing mind without adaptive regulation still moves slowly, and adaptive regulation without an innovation gateway has fewer ideas to admit (Table 1).

³ Source: compiled by the author

⁴ Source: compiled by the author

Table 1

Three pillars of the institutional mechanism⁵

Pillar	Function	Problem addressed
Directing mind	Single body coordinating infrastructure, operations, services [2]	Fragmentation
Adaptive regulation	Performance-based approval; fast track for safe innovations [1]	Regulatory gap
Innovation gateway	Single portal for startups, research, industry [3]	Barriers to external ideas

How prescriptive and adaptive regulation differ in practice is drawn out in Table 2. The contrast explains why merely deregulating is not the answer: safety cannot be abandoned, but the way it is assured can shift from fixed rules to demonstrated performance (Table 2).

Table 2

Prescriptive versus adaptive regulation⁶

Aspect	Prescriptive regulation	Adaptive (performance-based)
Basis	Fixed technical specifications	Demonstrated safety performance [1]
Response to new tech	Slow; requires rule change	Fast; evaluates outcomes
Innovation effect	Delays or denies [1]	Admits proven solutions quickly
Safety assurance	Compliance with rules	Evidence and data
Risk	Technology outpaces rules	Requires regulatory capability

For a national network reforming its institutions, the mechanism suggests sequenced entry points, summarised in Table 3. They begin with clarity of direction and proceed toward adaptive regulation, which is the hardest to build but the most decisive (Table 3).

Table 3

Sequenced entry points for institutional reform⁷

Step	Action	Expected outcome
1. Strategy	Adopt long-term rail strategy with innovation targets	Clear direction; investor certainty
2. Coordination	Strengthen single directing body	Reduced fragmentation
3. Gateway	Launch innovation portal for external ideas	Faster technology induction
4. Adaptive regulation	Shift to performance-based approval	Closing the regulatory gap

What does this diagnosis change for the reformer? Most institutional reforms of railways focus on ownership and structure — who runs the trains, how many bodies oversee them. These questions matter, but they miss the deeper obstacle. A perfectly structured, well-owned railway can still smother innovation if its regulator evaluates a predictive-maintenance algorithm by rules written for scheduled inspection. Reframing the problem as a regulatory gap redirects attention from the ownership of the sector to the responsiveness of its rules — a shift that changes which reform matters most.

The three pillars are deliberately interdependent, and it is worth being explicit about why none suffices alone. A directing mind cures fragmentation but can, if poorly designed, simply centralise slowness — a single body can be as cautious as many. Adaptive regulation matches the pace of technology but has little to admit if no channel brings external ideas to its door. An innovation gateway invites startups and researchers but frustrates them if approval still crawls. The mechanism works because each pillar covers a gap the others leave open; removing any one reopens the failure the whole was meant to close.

There is an honest tension at the centre of adaptive regulation that should not be glossed over. Performance-based approval is faster precisely because it trusts evidence over fixed rules — but that trust presupposes a

⁵ Source: compiled by the author

⁶ Source: compiled by the author

⁷ Source: compiled by the author

regulator capable of evaluating novel evidence competently. A weak regulator granted discretion may approve the unsafe as readily as the innovative; the safeguard of prescriptive rules, for all its rigidity, demands less capability. Moving to adaptive regulation therefore cannot be a mere policy declaration; it requires simultaneous investment in regulatory expertise. For a developing network this is the crux: the gateway and the directing mind are organisationally straightforward, but building a regulator that can judge innovation on its merits is the true institutional challenge.

The limits of the study should be stated plainly. The mechanism describes institutional architecture and the function of its components, but does not specify the legal instruments or the distribution of powers, which depend on each country's constitutional and administrative order. The regulatory gap is presented conceptually; its measurement for a specific network — how long innovations actually wait for approval — would require empirical study. Assessing the balance of public and private roles appropriate to a given national context is a further boundary condition and a natural continuation of this work.

CONCLUSIONS AND SUGGESTIONS

The institutional obstacle to railway innovation is not primarily a matter of who owns the network but of how fast its rules can admit what technology makes possible. The mechanism developed here places this regulatory gap at its centre and closes it through three interdependent pillars — a directing mind against fragmentation, adaptive regulation matched to the pace of technology, and an innovation gateway for external ideas — bound together by long-term strategy above and by delivery with feedback below.

The principal conclusion is that restructuring ownership, however necessary, does not by itself make a railway innovative; what does is aligning the speed of institutional admission with the speed of technological change. For a national network the sequence matters: clarity of strategy and a coherent directing body come first, but the decisive and most demanding step is the move to adaptive, performance-based regulation, which cannot succeed without a parallel investment in regulatory capability. Further work lies in measuring the regulatory gap empirically and in designing the legal instruments that fit a specific national context.

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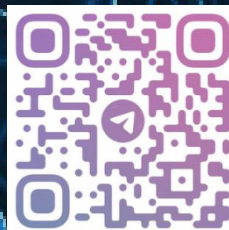
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