Government Publications Registration Number
11-1051000-100068-01

Knowledge Sharing Program

Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia

Slovakia

2024/25 KSP POLICY BRIEF

Presented by the MOEF, Republic of Korea

Ministry of Economy and Finance

KDI Korea Development Institute

Presented by the MOEF, Republic of Korea

2024/25 KSP POLICY BRIEF

Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia

Slovakia

Ministry of Economy and Finance
KDI Korea Development Institute

Project Title: Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia

Prepared for
The Government of the Slovak Republic

In Cooperation with
Ministry of Economy (MoE) and Slovak Innovation and Energy Agency (SIEA), Slovak Republic

Supported by
Ministry of Economy and Finance (MOEF), Republic of Korea

Prepared by
Korea Development Institute (KDI)

Project Director
Jungwook Kim, Executive Director, Center for International Development (CID), KDI

Project Manager
Seo Young Kim, Director, Division of Policy Consultation and Planning, CID, KDI

Project Officer
Gihyeon Hong, Senior Research Associate, Division of Policy Consultation and Planning, CID, KDI

Senior Advisor
Yoon Kyung Kim, Former Director General of the International Finance Bureau, MOEF

Principal Investigator
Joonghae Suh, Senior Fellow Emeritus, CID, KDI

Authors
Joonghae Suh, Senior Fellow Emeritus, CID, KDI
Vladimir Tanistrak, Head State Counsellor, Department of Strategy, MoE
Jun Ho Jeong, Professor, Department of Real Estate, Kangwon National University
Jaepil Han, Professor, Department of Economics, Chungnam National University
Artur Bobovnicky, Project Manager, SIEA
Yoon Hee Ha, Professor, Graduate School of Energy and Environment, Korea University (KU)
Jiho Song, Researcher, Graduate School of Energy and Environment, KU
Lucia Bogdanyova, Director, International Cooperation Department, SIEA

Local Consultants
Michelle Ostrihon Chmelova, Head of Competitiveness Department, SIEA

English Editor
Korea Institute of Culture and Arts Translation

Government Publications Registration Number 11-1051000-100068-01
ISBN 979-11-7566-012-0 94320
979-11-5932-110-8 (set)

2024/25 KSP POLICY BRIEF

Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia

Slovakia

Preface

In recent years, the global community has faced an increasingly complex set of challenges, including geopolitical tensions, disruptions in global supply chains, and the accelerating impacts of climate change. These trends have placed significant pressure on the international development landscape, with a noticeable decline in overall development finance. At the same time, development cooperation is evolving toward a more reciprocal and strategic approach that emphasizes mutual learning and shared benefits. Despite these challenges, collaboration remains essential for achieving lasting progress. Sustainable development requires countries to work together toward shared goals and to build partnerships that foster shared prosperity. By drawing on the diverse knowledge, policy experiences, and innovations that each country offers, the global community can find practical solutions to today's challenges and create pathways toward inclusive and sustainable growth.

The Knowledge Sharing Program (KSP), launched by Korea's Ministry of Economy and Finance (MOEF) in 2004, has served as a vital platform for sharing Korea's development experiences globally over the past 20 years. In addition to embedding joint research outcomes into the policies of partner countries, the KSP has advanced various international projects and highlighted the value of knowledge sharing in tackling global challenges together. In recent years, the program has also broadened its horizons through collaboration with advanced economies, further expanding the scope and diversity of its partnerships.

Since its inception, the Korea Development Institute (KDI) has participated in implementing the KSP, collaborating with more than one hundred countries. As Korea's leading think tank, the KDI has addressed a broad spectrum of issues faced by partner countries, from industrial development to digital transformation. During the 2024/25 KSP cycle, the KDI has undertaken twenty-three policy consultation projects that reflect the needs of partner countries.

Among the notable projects, 'Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia' led by the Slovak Innovation and Energy Agency (SIEA) under the Ministry of Economy exemplifies the spirit of international cooperation. On behalf of KDI, I would like to extend sincere appreciation to the Government of Slovak Republic, especially Vladimír Šimoňák for his continued leadership and insight. I would also like to express my special appreciation to Ms. Katarina Augustini and Mr. Martin Svoboda for their dedicated project management and valuable support throughout the process. I also wish to thank the KSP consultation

team—Senior Advisor Mr. Yoon Kyung Kim, Principal Investigator Dr. Joonghae Suh, researchers Dr. Jun Ho Jeong, Dr. Jaepil Han, and Dr. Yoon Hee Ha—and to the local consultants Mr. Vladimir Tanistrak, Dr. Michelle Ostrihon Chmelova, Dr. Artur Bobovnicky, and Ms. Lucia Bogdanyova for their dedicated and constructive contributions throughout the project. Special thanks also go to the Center for International Development (CID) at KDI, particularly Executive Director Dr. Jungwook Kim, Project Manager Dr. Seo Young Kim and Project Officer Mr. Gihyeon Hong for their diligent and consistent coordination throughout the project.

This Policy Brief presents key findings and practical policy options developed through the 2024/25 KSP consultation process. It is designed to meet the needs of both decision-makers and implementers by providing clear, context-aware insights drawn from collaborative research. We hope it serves not only as a reference, but as a catalyst for informed policy action in our partner countries.

This year's KSP laid a solid foundation for future-oriented cooperation between Slovakia and Korea—promoting practical policy exchange, strengthening mutual trust, and advancing our shared commitment to sustainable development. We are confident that this partnership will continue to deepen and contribute meaningfully to the long-term partnership between the two countries.

Cho, Dongchul
President
Korea Development Institute

Contents

Tables

Tables

Summary

Context

The 2024-25 Korea-Slovakia KSP examined policy frameworks for Slovakia's economic transformation, drawing on lessons from Korea's development trajectory. The central premise is Slovakia's urgent need to transition from its current FDI-centric growth model, which has generated high growth but reinforced regional disparities, toward an innovation-driven approach that supports balanced national development.

While foreign direct investment (FDI) has been a major driver of growth, particularly in the automotive sector, this growth strategy is approaching diminishing returns. Key challenges include an innovation deficit, brain drain, and persistent regional inequality. The proposed strategy emphasizes economic diversification, robust domestic innovation, stronger linkages between multinational and local firms, support for SME growth, and targeted regional development initiatives.

Korea's experience highlights the effectiveness of long-term, government-led, and adaptive policy frameworks that foster endogenous growth. This includes institutionalized support for university-industry cooperation, comprehensive SME digitalization, and cohesive national strategies for emerging industries such as hydrogen.

Topic 1: Post-FDI Strategy and Policy for Balanced National Development

- Transition from FDI-Driven Growth: Slovakia's rapid growth through FDI, particularly in the automotive sector, is approaching diminishing returns. This has resulted in a narrow economic base, limited domestic value addition, and persistent regional disparities. A structural transformation is urgently required.
- Lessons from Korea's Evolution: Korea's transition from capital accumulation to balanced growth revealed challenges such as regional inequality and the impact of technological change on labor demand. Its experience underscores the importance of long-term vision, adaptive policies, local initiative, and strong governance in regional development.
- Suggestions for Slovakia: Recommendations include diversifying the economic base into emerging sectors (e.g., IT, renewables, advanced manufacturing), strengthening domestic innovation and R&D (by increasing public investment, supporting startups), enhancing linkages between multinationals and domestic firms, promoting SME growth, and designing targeted development programs for lagging regions.

Topic 2: Addressing Regional Disparities in Slovakia: Lessons from Korea's University-Industry Cooperation Policy

- **Persistent Regional Inequality:** Both Slovakia and Korea exhibit metropolitan centered development, but Slovakia faces deeper structural challenges in regional inequality and significant "brain drain" due to a weak innovation ecosystem.
- **Korea's Long-Term UIC Commitment:** Korea's success in university-industry cooperation (UIC) is attributed to sustained long-term policy commitment, robust legal frameworks (e.g., the University-Industry Cooperation Act), and consistent programmatic and financial support programs (e.g., HUNIC, LINC, and RISE programs).
- **Strategic UIC Recommendations for Slovakia:** Slovakia should pursue three interlinked strategies: (i) implementing an AI-powered digital matchmaking platform to connect universities and industry; (ii) institutionalizing long-term cooperation through a "Family Company" model that aligns university outputs with industry needs; and (iii) expanding the "Living Lab" approach to embed universities in local communities for real-world problem-solving.

Topic 3: SME Digitalization for Balanced National Development in Slovakia: Policy Analysis and Strategic Recommendations

- **Slovakia's Digitalization Ambitions and Challenges:** Slovakia recognizes SME digitalization as critical for competitiveness and balanced development, consistent with EU frameworks. However, implementation is hindered by procedural delays, institutional fragmentation among agencies, overreliance on external (EU) funding, and persistent regional disparities in digital readiness.
- **Korea's Integrated Digital Inclusion Programs:** Korea's early 2000s experience provides valuable lessons, having successfully addressed digital divides through long-term, integrated programs such as the "One Million SMEs Informatization Plan," "Information Network Village," and extensive digital literacy initiatives. Institutionalized funding mechanisms and cross-ministerial coordination supported these efforts.
- **Strategic Pillars for Slovakia's SME Digitalization:** Recommendations include establishing strong and visible digital leadership (e.g., appointing a National Digital Leader); strengthening the domestic digital ecosystem by nurturing local solution providers; and stimulating domestic demand for digital services (through measures such as public procurement policies and shared platforms). Effective implementation of these pillars requires unified governance, legal reforms, a dual-track education and training system, and the establishment of territorial digital support hubs.

Topic 4: A Strategic Framework for Korea-Slovakia Hydrogen Cooperation

- **Korea's Holistic Hydrogen Playbook:** Korea's comprehensive hydrogen strategy, established under the Hydrogen Economy Promotion and Safety Management Act, is coordinated by a Prime Minister–led committee, robust market-creation tools (e.g., the Clean Hydrogen Portfolio Standard, tax credits), a strong safety management system, targeted R&D investment, and nationwide human capital development.
- **Key Lessons for Slovakia:** Slovakia can draw from Korea to strengthen investor confidence, the importance of a binding legal framework with multi-year targets for investor confidence, demand-pull instruments such as Contracts for Difference (CfDs); dedicated safety laws and regulatory agencies; an integrated innovation ecosystem connecting R&D and workforce development; a focused industrial policy on critical materials; and the creation of regional "Hydrogen Valleys."
- **Phased Bilateral Cooperation Agenda:** A structured Korea-Slovakia hydrogen cooperation framework for 2025–2035 is proposed. The agenda includes: for foundation (aligning standards, feasibility studies), demonstration and localization (pilot joint manufacturing, co-branded refueling stations), and commercial scale-up (direct reduced iron production, infrastructure knowledge exchange). This cooperation seeks to integrate Slovakia into the Central European Hydrogen Corridor and foster the development of a resilient hydrogen sector.vulnerable populations, mobilizing green bonds via state-backed securitization, and ensuring a just transition in the coal sector through diversification strategies.

1. Introduction: Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia

The 2024-25 Korea-Slovakia Knowledge Sharing Program (KSP) addresses Slovakia's urgent need to shift from its current foreign direct investment (FDI)-focused growth model to a more sustainable, innovation-driven economy. While Slovakia's FDI-focused strategy has delivered impressive economic growth, particularly in the automotive sector, this approach has created structural vulnerabilities that now necessitate a strategic reorientation. The program draws from Korea's development experiences, offering valuable insights for Slovakia's economic transformation.

Slovakia's economic success over the past two decades has been built on attracting foreign investment, positioning the country as a hub for automobile manufacturing within the European Union. This strategy has yielded rapid GDP growth, job creation, and industrial modernization. However, the economy remains narrowly concentrated in specific sectors, with limited domestic value addition and persistent regional disparities. Most concerning is the innovation deficit coupled with significant brain drain as skilled professionals seek opportunities in more innovation-rich environments.

Korea's development experience offers compelling parallels for Slovakia's current predicament. Korea successfully navigated a transition from capital accumulation-based growth to an innovation-driven economy. Korea’s experience underscores the crucial importance of a long-term vision, adaptable policy frameworks, and effective institutional governance in guiding economic transformation. Korea's evolution demonstrates that sustainable development necessitates cultivating endogenous innovation capabilities, strengthening domestic enterprises, and promoting equitable regional development. As the Korean economy advances, regional disparities become wider, which is a counterexample of balanced national development.

The KSP framework addresses four interconnected dimensions of Slovakia's transformation challenge. First, it examines the shift from FDI-driven growth toward balanced national development, drawing on Korea's experience in managing structural transitions. Second, it explores strategies for addressing regional disparities through enhanced university-industry cooperation, leveraging Korea's institutional collaboration models. Third, it examines the critical role of SME digitalization in achieving balanced development, drawing on lessons from Korea's comprehensive digital inclusion programs. Finally, it presents a policy framework for emerging sectors, specifically hydrogen economy development, where Korea-Slovakia cooperation can create mutual benefits.

Korea’s experience highlights critical success factors for Slovakia's transformation, including sustained political commitment across electoral cycles, institutional capacity building, adaptive policy frameworks, and coordinated government intervention. Korea's success was a result of strategic government leadership, long-term planning, and the careful cultivation of domestic capabilities alongside international partnerships. This program aims to juxtapose two paths of development that Korea and Slovakia have successfully trodden over the years, and to derive policy lessons that can inform Slovakia's transformation toward a more innovative and balanced economy.

2. Post-FDI Strategy for Balanced National Development: Korea's Trajectory and its Implications for Slovakia

Korea's economic development trajectory since the 1960s represents one of the most remarkable transformations in modern economic history. This journey, often referred to as the "Miracle on the Han River," was initially characterized by state-led industrialization, strategic capital allocation, and export-oriented growth. However, the 1997 Asian financial crisis that hit many Asian countries, including Korea, exposed fundamental vulnerabilities in this development model. The crisis precipitated a comprehensive reorientation toward market liberalization, institutional reform, and innovation-driven growth.

The report examines this transformation through three interconnected lenses: shifting growth patterns, changing income distribution dynamics, and evolving regional development trajectories. It then analyzes Korea's post-crisis policy initiatives—specifically Free Economic Zones (FEZs), Special R&D Zones, and regional industrial clusters—before drawing comparisons with Slovakia's development challenges. The report draws key policy lessons from Korea's experience, offering valuable insights for Slovakia and similar economies seeking balanced national development in the post-industrial era.

2.1. Korea's Economic Transformation: From State-Led Growth to Market-Driven Innovation

Shifting Growth Patterns

Before the 1997 crisis, Korea exemplified the developmental state model, with the government exercising substantial control over capital allocation through its influence over the banking sector. This system facilitated extraordinary industrialization, with annual GDP growth rates consistently reaching 7 to 10%, among the highest worldwide. The state-business relationship centered on promoting chaebols (family-owned conglomerates) as national champions in strategic sectors, enabling rapid industrial upgrading from light manufacturing to heavy industries and eventually to electronics and automobiles.

This growth model featured several distinctive characteristics:

- High leverage ratios (frequently exceeding 400% debt-to-equity) enabled rapid capital accumulation.

- Complex cross-guarantees within chaebol groups facilitated resource allocation but created systemic vulnerabilities.
- Financial regulation remained subordinate to industrial policy objectives.
- The domestic market remained relatively protected despite export orientation.

The 1997 financial crisis and subsequent IMF-mandated reforms fundamentally reconfigured Korea's growth model through the "four-sector reforms," which encompassed financial sector restructuring, corporate governance enhancements, labor market liberalization, and public sector reorganization. These structural adjustments produced several significant changes:

- Growth rates moderated to a more sustainable 3 to 5% annually.
- The financial sector underwent substantial liberalization and strengthening of regulatory oversight.
- Corporate governance reforms reduced excessive leverage, with typical debt-to-equity ratios declining to below 100%.
- The economic structure shifted toward a greater emphasis on services, technology, and knowledge-based industries.

While this post-crisis model demonstrated greater resilience during subsequent global economic shocks (notably the 2008 Global Financial Crisis), it also coincided with slowing productivity growth and increasing concerns about innovative capacity in the absence of the developmental state's coordinating mechanisms.

Income Distribution: From Equity to Polarization

Korea's pre-crisis development was notable for achieving "growth with equity," combining rapid industrialization with a relatively equitable distribution of economic benefits. Labor-intensive industrialization generated widespread employment opportunities; universal education produced a relatively homogeneous workforce; and compressed wage structures limited internal inequality. Consequently, Korea maintained moderate income inequality, with Gini coefficients typically ranging from 0.2315 in 1971 to 0.3205 in 1999.

The post-crisis period, however, witnessed a radical alteration of Korea's distributional dynamics. Labor market reforms have created a pronounced dualization between protected, well-compensated employees in large corporations and the public sector, and precarious workers in small enterprises, non-standard employment arrangements, and the service sector. This bifurcation manifested in various dimensions:

- Wage polarization intensified between high-skill and low-skill workers.
- Employment security declined significantly, particularly for younger workers.
- Asset inequality expanded dramatically, driven by the appreciation of property prices in metropolitan areas.

- Extreme elderly poverty emerged, with Korea developing one of the highest elderly poverty rates among OECD countries (exceeding 40% as of 2020).
- Educational expenditure stratification increased as families invested heavily in private tutoring and other forms of supplementary education.

These distributional shifts reflected the fundamental reconfiguration of Korea's social contract, with market mechanisms assuming greater importance in determining economic outcomes. Growing inequality has become a significant source of social tension and political contention.

Regional Development: From Strategic Decentralization to Metropolitan Concentration

Before the 1997 crisis, Korea's regional development reflected the developmental state's strategic efforts to balance the geographic distribution of economic activity. The government actively pursued industrial decentralization through specialized industrial complexes in regions outside Seoul, including Ulsan (shipbuilding, automotive), Pohang and Gwangyang (steel), Gumi (electronics), and Changwon (machinery). These initiatives created significant manufacturing centers across the national territory, partially offsetting the Greater Seoul Metropolitan Area's (GSMA) primacy.

The post-crisis period, however, witnessed accelerated concentration trends and more pronounced regional disparities. The GSMA dramatically increased its economic dominance, expanding its share of national GDP from approximately 42% before the crisis to over 50% in subsequent decades. Population concentration similarly intensified, with the capital region accounting for nearly half of the national population.

Several factors have led to this accelerated concentration:

- The post-crisis growth model emphasized knowledge-intensive services, technology, and creative industries—sectors that benefit disproportionately from agglomeration economies.
- Financial activities became increasingly centralized, with the Seoul metropolitan area accounting for over 70% of financial transactions.
- Corporate headquarters functions are concentrated dramatically, with over 90% of major corporations establishing their command centers in the capital region.
- Higher education institutions and R&D facilities are concentrated in and around Seoul, thereby reinforcing the region's human capital advantages.
- Infrastructure investment, while nominally balanced, is often prioritized for connectivity to the capital region.

This intensified spatial concentration created challenges for balanced national development, with non-metropolitan regions struggling to retain talent, attract investment, and develop innovation ecosystems.

2.2. Korea's New Growth Initiatives: Case Studies

The report analyzes three major policy initiatives introduced by the Korean government to stimulate regional growth: Free Economic Zones, Special R&D Zones, and Regional Clusters. While these policies employ distinct terminology to articulate their objectives, they share the common goal of strengthening the regional growth capacity. The key features of these three policies are summarized in the following table.

Table 1.
Three Policies in Comparison

	Regional Clusters	Free Economic Zones	R&D Special Zones (Innopolises)
Objective	Creating growth engines	Attract foreign investment	Promote R&D-business nexus
Policy Tools	Provision of an industrial complex Moderate incentives	Provision of land Package of incentives	R&D collaboration, technology transfer Business incubation
Focus	Upgrade manufacturing	Comprehensive, including logistics	R&D & business creation
Source of Advantage	Mass production (scale effect)	Location, regional strongholds (agglomeration economy)	Knowledge base (spillover effect)
Governance	Government: central + local (minor) Intermediary: Techno-parks	Central government + agency Intermediary: diverse (hybrid)	Central government Intermediary: R&D Foundation
Performance	· Good: capital regions · Declining: non-capital regions; exception: Changwon, Wonju	· Good: Incheon · Moderate: Busan-Jinhae, Gwangyang Bay · Poor: others	· Good: Daedeok · Moderate · Poor: others
Limitation	Local industries are failing to revive	Businesses are not moving in	Business dynamics are weak
Response	Renovate infrastructure, digital/green transformation	Re-structure policy framework	Re-orient R&D-business nexus (e.g., spin-offs)

Source: Author.

Free Economic Zones (FEZs)

In response to the 1997 financial crisis, Korea established Free Economic Zones (FEZs) to attract foreign direct investment, foster innovation, and create globally competitive business environments. These zones offered regulatory flexibility, tax incentives, and advanced infrastructure designed to appeal to international investors and knowledge-intensive industries.

The performance of FEZs has been mixed. While some zones (particularly Incheon and Busan-Jinhae) have succeeded in attracting significant investment and promoting exports, others have struggled with underutilization and limited impact. Their overall contribution to balanced regional development has been modest, as FEZs have often reinforced existing patterns of regional advantage rather than fundamentally transforming them.

Key lessons from the FEZ experience include:

- The importance of strategic location and connectivity to global markets
- The need for complementary investments in human capital and innovation ecosystems
- The challenge of creating genuine spillovers to local economies
- The limitations of regulatory and tax incentives without broader institutional reforms

Special R&D Zones

The Daedeok Innopolis in Daejeon represents Korea's flagship research and development (R&D) cluster, bringing together research institutes, universities, and high-tech firms in a regionally concentrated innovation ecosystem. Established initially as a government research complex in the 1970s, it evolved into a more dynamic innovation hub following the 1997 crisis, with increased emphasis on commercialization and entrepreneurship.

The success of Daedeok Innopolis is attributed to several factors:

- Sustained government investment over multiple decades
- Critical mass of research institutions and human capital
- Strong linkages between research and industry
- Supportive ecosystem for startups and technology commercialization

The Daedeok experience demonstrates the potential for creating innovation hubs outside the capital region, but also highlights the long timeframes and substantial investments required for such initiatives to mature.

Regional Industrial Clusters

Korea has pursued various approaches to regional cluster development, including:

- Transformation of traditional industrial parks (e.g., Guro Industrial Park's evolution from labor-intensive manufacturing to digital industries)
- Specialized industry clusters (e.g., Wonju Medical Equipment Cluster)
- Technology-focused parks (e.g., the national network of Techno-Parks)

These initiatives have shown varying degrees of success. Key factors influencing outcomes include:

- Alignment with regional comparative advantages and existing industrial bases

- Quality of industry-academia-government collaboration
- Access to a skilled workforce and specialized infrastructure
- Integration with global value chains and markets
- Governance structures and stakeholder engagement

The mixed performance of regional clusters underscores the challenges of replicating successful models across diverse regional contexts and the importance of tailoring approaches to local conditions.

2.3. The Slovak Case: Comparative Insights

Slovakia shares certain similarities with Korea, having undergone rapid industrialization and integration into the global economy. Like Korea, Slovakia has experienced significant regional disparities, with economic activity and innovation concentrated in the capital region, Bratislava, and the western parts of the country. In contrast, the eastern and rural regions lag.

The Slovak economy has been heavily shaped by FDI, particularly in the automotive and electronics sectors. While this FDI-driven growth has brought significant economic benefits, it also introduces vulnerabilities, such as reliance on foreign decision-making, limited domestic innovation, and uneven regional development.

Slovakia's policy challenges include:

- Diversifying beyond manufacturing and moving up value chains
- Building indigenous innovation capacity
- Addressing persistent regional disparities
- Developing human capital to support knowledge-based industries

These challenges parallel Korea's post-crisis experience, making Korea’s policy lessons particularly relevant for Slovakia's current development stage.

2.4. Policy Lessons

Korea's experiences provide important policy lessons for countries seeking balanced national development in the post-FDI era. The following lessons are especially relevant for Slovakia and similar economies.

Recognize the Limits of FDI-Led Growth for Regional Balance

FDI as a catalyst and a constraint: While FDI can accelerate industrialization and technology transfer, it often gravitates to regions with established infrastructure and human capital, reinforcing existing disparities. Korea's experience shows that without

complementary regional policies, FDI alone cannot ensure balanced development.

- Governments need to actively guide FDI toward lagging regions through targeted incentives, infrastructure investment, and support for local capacity-building.
- FDI attraction should be complemented by policies to develop indigenous capabilities and foster local entrepreneurship.
- Sectoral diversification strategies should target activities with potential for broader regional distribution.
- Policies should promote the linkage of FDT with local firms and institutions.

Prioritize Institutional Innovation and Ecosystem Building

Beyond physical infrastructure: The success of Daedeok Innopolis underscores the importance of building robust innovation ecosystems: networks of firms, research institutions, universities, and government agencies that collaborate, share knowledge, and foster entrepreneurship.

- Invest in institutional capacity, governance structures, and collaborative platforms that facilitate knowledge exchange and innovation
- Support intermediary organizations that bridge gaps between research, industry, and government
- Develop specialized services and support mechanisms for startups and scale-ups
- Foster a culture of experimentation, risk-taking, and continuous learning
- Create mechanisms for managing intellectual property and facilitating technology transfer

Ensure Long-Term Commitment and Policy Consistency

Sustained investment: The development of successful clusters requires decades of consistent public investment, policy stability, and adaptive governance. Short-termism or fragmented efforts are unlikely to yield transformative results.

- Establish long-term strategic frameworks that transcend political cycles
- Secure stable funding mechanisms that provide predictability for stakeholders
- Establish institutional arrangements that ensure policy continuity while allowing for flexibility and adaptation, thereby facilitating effective governance
- Develop phased implementation plans with clear milestones and evaluation points
- Build broad stakeholder coalitions to sustain commitment across political transitions

Tailor Cluster and Innovation Policies to Local Contexts

No "uniform model": The mixed performance of Korea's regional clusters demonstrates the need for policies that are sensitive to local strengths, capabilities, and market realities.

- Conduct thorough regional diagnostics to identify genuine comparative advantages
- Engage local stakeholders in the development and implementation of strategies
- Design cluster initiatives that build on existing strengths rather than imposing external models
- Adapt policy instruments to the specific needs and capacities of different regions
- Recognize the diversity of potential development paths beyond high-tech manufacturing

Policy Learning

Adaptive policy: Korea's experience demonstrates the value of continuous monitoring, rigorous evaluation, and a willingness to adjust policies in response to outcomes and changing circumstances.

- Devolve meaningful authority and resources to regional and local governments
- Build capacity in regional institutions to design and implement development strategies
- Establish robust mechanisms for data collection, impact assessment, and policy feedback to ensure effective decision-making and informed policy development
- Establish institutional arrangements for regular policy reviews and adaptations

Balance Specialization and Diversification in Regional Economies

Resilience through diversity: While smart specialization can enhance competitiveness, excessive dependence on a single industry or firm creates vulnerability, as seen in some of Korea's industrial regions.

- Promote related variety—diversification into adjacent fields that can leverage existing capabilities
- Support the development of complementary activities within regional economies
- Encourage innovation at the interfaces between different sectors and technologies
- Develop strategies for managing industrial transitions and structural change

3. Industry-University Cooperation for Balanced National Development: Lessons from Korea for Slovakia

As Slovakia seeks to transition toward an innovation-driven, inclusive economy, the challenge of regional disparity remains an obstacle. Economic activity, research, and development are heavily focused in Bratislava, the capital city, leaving other regions underused and deepening the center–periphery divide. Recognizing these challenges, the Slovak government has launched a series of policy initiatives to promote balanced national development and ensure that the benefits of an innovative economy are more broadly shared. This report aims to inform Slovakia's regional innovation policy by drawing on lessons from Korea's experience with university–industry–government collaboration.

The report builds on two previous KSP policy consultations, "Performance Enhancement of Support Tools for the Development and Deployment of Industry 4.0 Elements in the SME Environment" (2022/23) and "Networking as a Lever for Improving Innovation Ecosystem of Slovakia" (2023/24), and extends these efforts by exploring more systematic approaches to national innovation policies. The focus is on university–industry cooperation (UIC) as a central pillar of balanced regional development. Korea's policy journey, characterized by ongoing commitment to UIC and the development of the Regional Innovation System (RIS), would offer a valuable comparative perspective for Slovakia, considering the structural similarities in their patterns of capital region-focused growth.

3.1. Regional Growth and Disparities in Korea and Slovakia

OECD's Functional Typology of Regions

To understand the spatial dynamics of regional growth, the report adopts the OECD's functional typology of regions, which classifies areas not by administrative boundaries but by accessibility to urban centers and the quality of infrastructure (Fadic *et al*., 2019). This approach categorizes regions into metropolitan and non-metropolitan areas, further distinguishing them by city size and travel time to urban centers (OECD, 2024). Under this framework, both Korea and Slovakia are characterized by a high concentration of population in metropolitan areas. However, Slovakia features a relatively larger share of its population in medium-sized functional urban areas (FUAs), whereas Korea's population is more polarized between large metropolitan centers and remote areas.

Regional Growth Regimes

The report compares regional growth regimes in Korea and Slovakia from 2000 to 2019 (Garcilazo *et al*., 2021). Both countries experienced similar average GDP growth rates (3.8% for Korea and 3.9% for Slovakia), but the spatial patterns of growth differed. In Korea, economic growth was primarily driven by the largest metropolitan centers and adjacent non-metropolitan regions, with mid-sized metropolitan areas lagging. Both medium-sized metropolitan and non-metropolitan areas led Slovakia's growth, while smaller non-metropolitan regions underperformed.

Population growth patterns mirror these trends: Korea's population is increasingly concentrated in large metropolitan areas, while Slovakia also sees growing concentration in and around its metropolitan centers. Productivity gains are similarly concentrated, with metropolitan regions and their surroundings contributing disproportionately to labor productivity growth. This spatial concentration of economic activity and productivity underscores the challenge of achieving balanced regional development in both countries.

The brain drain phenomenon unfolds in somewhat different ways in Korea and Slovakia. In Korea, brain migration from the provinces to the capital region is common, with less severe outflows overseas. Slovakia is experiencing both. Brain drain is often dominated by the outflow of highly productive local talent, which in turn leads to a decline in the average productivity of human capital and a weakening of the local innovation ecosystem.

3.2. Evolution of University–Industry Collaboration in Korea

Policy Evolution and Institutional Framework

Korea's approach to university–industry–government collaboration has evolved over two decades, reflecting changing policy priorities across successive administrations:

- Roh Moo-hyun and Lee Myung-bak administrations: Emphasized university-led knowledge transfer and direct support for businesses
- Park Geun-hye administration: Shifted focus to entrepreneurship and job creation, encouraging universities to play a more active role in regional economies
- Moon Jae-in administration: Highlighted social innovation and regional engagement, promoting living labs and collaborative platforms
- Yoon Suk Yeol administration: Advocates for a regionally driven model of UIC, granting greater autonomy to local actors

Throughout these shifts, Korea has maintained a consistent policy commitment to UIC as a driver of regional innovation and balanced growth. The Regional Innovation System

(RIS) has served as the institutional backbone, supporting the creation of regional innovation clusters, living labs, and family company programs that link universities with local industry and government stakeholders. Since the 2000s, as innovation-driven regional development models gained prominence, the government's UIC policy has moved in two directions. First, it began expanding financial support for universities as the main players in UIC, and second, it has undertaken work to build UIC infrastructure. Specifically, the goal of the latter was to create an environment that fosters endogenous innovation by local actors through the RIS framework. Government projects related to infrastructure development have been implemented in two ways, as outlined in the table below.

Table 2.
Comparison of Major Infrastructure Projects Supporting University–Industry Collaboration

	Industrial Complex-Centered (Within the Complex)		University-Centered (Within the University)	
Projects	Industrial Complex Campus Project	University–Industry Convergence District Project	University–Industry-Research Cooperation Complex	Campus Innovation Park
Ministries	Ministry of Education	Ministry of Industry	Ministry of Education	MOE, MOLIT, MSS
Objectives	Relocation of university education and research functions to (or near) industrial complexes to foster spatial integration with industry	Spatial integration of universities and industrial complexes with a practice-oriented cooperative education system	Remodeling idle university space to attract industry and research, and build a university–industry-research innovation platform	Developing industrial complexes on idle university land with integrated business, residential, cultural, and welfare facilities
Year of Inception	2011-	2011-	2019-	2019-
Applicants	Universities with campuses in or adjacent to industrial parks	Public-private nonprofit corporation or consortium for university–industry cooperation	Universities, vocational colleges	Universities and vocational colleges, excluding campuses located in Seoul
Duration	3 yrs.	5 yrs.	5 yrs.	Varying by eligible recipients
Government Expenses	Around KRW 1 billion per year	Around KRW 17 billion per year	Around KRW 2 billion per year	Non-capital region: KRW 190.5 billion Capital region: KRW 95.2 billion
Outcomes	As of 2024, 42 industrial park campuses are in operation.	As of 2024, 17 districts have been selected and supported.	2 (2019), 2 (2020), and 4 (2024)	3 (2019), 2 (2021), 2 (2022), and 2 (2023)

Notes: 1) The Government's expenses for Campus Innovation Parks are based on 2019 projects.
2) MOE (Ministry of Education); MSS (Ministry of SMEs and Startups); MOLIT (Ministry of Land, Infrastructure and Transport)

Source: Updated by author based on Table 5 in Hwang and Park (2021).

Key Achievements

Korea's UIC policies have produced several notable outcomes (Ministry of Science and ICT, 2017):

- Knowledge Transfer and Commercialization: Universities have become active participants in regional economies, supporting the transfer of technology and entrepreneurship.
- Regional Innovation Clusters: RIS and related initiatives have fostered the emergence of innovation clusters outside the capital region, promoting more geographically balanced development.
- Living Labs and Family Companies: These programs have provided platforms for collaborative problem-solving, skills development, and the co-creation of solutions to regional challenges.
- Region's growth engine: Entrepreneurial universities, which did not exist in the past, cultivate entrepreneurship among professors, researchers, and students, directly contributing to the economic growth of the region.

Limitations and Ongoing Challenges

Despite these achievements, limitations persist. The effectiveness of UIC varies widely by region, with leading universities and industries in metropolitan centers capturing a disproportionate share of benefits. In less-developed regions, weak institutional capacity, limited industry demand, and insufficient funding have constrained the impact of UIC initiatives. Furthermore, demographic decline and fiscal pressures threaten the sustainability of these efforts, underscoring the need for a more adaptive and regionally tailored approach (Joint Ministerial Press Releases, 2020).

3.3. University–Industry Collaboration in Slovakia: Current Landscape

Progress and Challenges

Slovakia has made some progress in strengthening UIC, but significant challenges remain (Rehák *et al*., 2019; Hrivnák and Jarábková, 2022; Lešková and Šipikal, 2019):

- Regional concentration: R&D and innovation activities remain heavily concentrated in Bratislava, with the peripheral regions lagging.
- Fragmented Ecosystem: Collaboration between universities and industry is often ad hoc, lacking the institutional depth and continuity seen in Korea's RIS.
- Limited Regional Capacity: Many regions lack the critical mass of skilled personnel, infrastructure, and industry demand needed to sustain dynamic UIC ecosystems.

Policy Context

The Slovak government has introduced various measures to address these challenges, including support for innovation clusters, technology transfer offices, and regional development agencies. However, these efforts have yet to produce a fully integrated and sustainable UIC ecosystem capable of driving balanced national development.

3.4. Policy Recommendations for Slovakia

The report offers a comprehensive set of policy recommendations, drawing directly from Korea's experience and tailored to Slovakia's context. These recommendations aim to enable Slovakia to utilize UIC as a catalyst for balanced regional development, reduce spatial disparities, and foster a more inclusive innovation ecosystem.

Establish a National Framework for Regional Innovation Systems (RIS)

- Institutionalization: Slovakia should develop a national RIS framework that formally integrates universities, industry, and local government as core partners in regional innovation. This framework should be codified in national policy and supported by dedicated funding streams.
- Third Mission Mandate: Universities should be encouraged—through policy and funding incentives—to adopt a "third mission" that extends beyond teaching and research, emphasizing their role as engines of regional economic and social development.
- Expand Living Labs and Family Company Programs: Collaborative platforms, such as living labs and family company programs, should be scaled up to bring together students, researchers, and local businesses to co-develop solutions to regional challenges. These platforms can foster practical skills, entrepreneurial mindsets, and real-world impact.
- Capacity Building: Investment in training and support for university technology transfer offices, entrepreneurship centers, and regional engagement units is essential. Such capacity-building efforts will enable universities to play a more proactive and effective role in regional innovation ecosystems.
- Defining a New UIC Policy Framework: To reverse brain drain, multiple policies need to work together. Above all, in regions, economic growth, technological innovation, and talent development should go together. Universities can play a key role in implementing these complex policies.

Foster Collaborative Platforms and Networks

- AI-Based UIC Platforms: Slovakia should develop digital platforms that facilitate matchmaking, knowledge sharing, and project collaboration between universities and industry. Drawing on best practices from Korea's AI-based UIC models, such platforms can reduce barriers to entry and enable more dynamic, data-driven collaboration.
- Regional Innovation Clusters: The formation of thematic clusters aligned with regional economic specializations (e.g., automotive, ICT, green technologies) should be supported. Universities can serve as anchors for these clusters, providing research expertise, talent, and infrastructure to support their growth and development.
- Cross-Regional Collaboration: Inter-regional partnerships should be promoted to share best practices, pool resources, and address common challenges. Such collaboration can help overcome the limitations of small regional markets and foster a culture of collective problem-solving.
- Continued efforts to build social capital: Collaborative networks evolve to become established as the backbone of regional innovation, based on trust between network actors. Continued support and efforts are necessary to ensure the maturation of this social capital.

Incentivize Industry Participation and SME Engagement

- Co-Funding Schemes: Co-financing mechanisms need to be introduced to encourage private sector investment in collaborative R&D and innovation projects. Public–private partnerships can leverage complementary strengths and share risks.
- Tax Incentives and Regulatory Support: Targeted tax breaks, regulatory flexibility, and procurement preferences would be provided for firms that engage in substantive UIC activities. These incentives can stimulate greater industry engagement and align business interests with national innovation goals.
- SME Engagement: Specific programs should be designed to involve small and medium-sized enterprises (SMEs) in UIC, recognizing their critical role in regional economies. Tailored support, simplified procedures, and networking opportunities can help SMEs overcome capacity constraints.

4. SMEs Digitalization for Balanced National Development in Slovakia: Challenges and Policy Implications

4.1. The Slovak Digitalization Landscape and the Role of SMEs

Slovakia's journey toward digital transformation is emblematic of the broader European and global push to harness digital technologies for economic growth, social inclusion, and national competitiveness. The Slovak government's policy trajectory, shaped by alignment with the European Union's Digital Agenda and the Digital Europe Programme (2021–2027), underscores a clear recognition of digitalization as a cornerstone of future development. Yet, despite ambitious targets and significant financial commitments—most notably, the allocation of EUR 1.29 billion under the National Recovery and Resilience Plan (NRRP)—the pace and depth of digital adoption, particularly among SMEs, remain insufficient (European Parliament, 2022).

This underperformance is starkly illustrated by Slovakia's position in the European Commission's Digital Economy and Society Index (DESI) 2022, where the country ranks 23rd out of 27 EU member states. While incremental improvements are observable, Slovakia's digital maturity lags behind EU averages, especially in the SME sector. Only 13% of Slovak SMEs engaged in online sales in 2023 (down from 17% in 2020), and a mere 16% utilize e-invoicing, compared to the EU average of 32%. The adoption of advanced digital technologies—such as big data analytics, cloud computing, and digital platforms—is even more limited, particularly in traditional sectors like manufacturing, agriculture, and retail, which collectively employ a significant share of the Slovak workforce (Slovak Alliance for Innovation Economy, 2023).

The persistence of these gaps is attributable to a confluence of structural, institutional, and socioeconomic factors. Notably, the spatial distribution of digital infrastructure is highly unequal: while urban centers like Bratislava enjoy near-universal connectivity, only 30% of rural households have access to Very High Capacity Networks (VHCN), compared to the EU average of 55% (European Commission, 2024). This digital divide not only restricts the participation of rural SMEs in digital ecosystems but also exacerbates broader regional disparities in economic opportunity and social inclusion.

Governance and policy execution further compound these challenges. Fragmented responsibilities, administrative burdens, and a lack of effective coordination characterize the Slovak policy landscape. These deficiencies hinder the implementation of digitalization initiatives and restrict the effectiveness of support mechanisms designed for SMEs.

Moreover, the workforce's digital skills gap—rooted in educational disparities and uneven access to training—remains a critical bottleneck. While 55% of adults possess at least basic digital proficiency (slightly above the EU average), this aggregate figure masks significant disparities across age, education, and region (Digital Coalition, 2023).

The COVID-19 pandemic, while accelerating digital adoption among some firms, also deepened existing disparities. Digitally advanced enterprises rapidly pivoted to online models, whereas many SMEs continued to rely on conventional practices, constrained by cost, capacity, and lack of support. The government's efforts to address these issues—through partnerships with organizations such as the Slovak Society for Computer Science and the ICDL Foundation, as well as initiatives like the IT Fitness Test —have made some progress but have not yet achieved comprehensive inclusion.

4.2. Korea's Experience: A Comparative Policy Perspective

Korea's experience with digitalization offers a valuable comparative lens for Slovakia. Beginning in the 1980s, Korea's informatization policy was marked by strong government leadership, phased infrastructure development, and a gradual shift from state-led to market-driven innovation. Key features of Korea's approach include:

- Strategic Infrastructure Investment: The National Basic Information System (NBIS) project, initiated in the late 1980s, prioritized the computerization of key sectors (administration, finance, education, defense) and the integration of information systems. The Korean government's commitment to localizing hardware and software, as well as building a robust communication network, laid the foundation for subsequent digital progress.
- Institutional and Legal Frameworks: Korea established dedicated agencies (e.g., National Computerization Agency) and enacted legislation to coordinate and standardize digitalization efforts, ensuring policy coherence and continuity.
- Human Capital Development: Recognizing the centrality of digital skills, Korea invested heavily in digital education and workforce training, fostering a culture of lifelong learning and adaptability.
- SME Support and Ecosystem Development: Korea's policies evolved to provide targeted support for SMEs, facilitating access to digital tools, fostering innovation networks, and promoting public-private partnerships.

Implementing these policies, Korea experienced trials and errors. For example, the Small Business Network Project faced poor quality of services due to the low capacity of application service providers. Demand from SMEs did not grow as expected, resulting in a low record of policy performance. A malfunction of the public data center caused severe service interruptions. Despite these limitations, however, the government's

policies were overall effective in fostering early adoption of digital technologies among SMEs and lowering entry barriers, thereby creating sustained demand for rapidly growing IT services.

Korea's trajectory underscores the importance of sustained leadership, adaptive policy frameworks, and the integration of infrastructure, skills, and institutional support. These lessons are particularly relevant to Slovakia's current challenges, specifically in the areas of governance, capacity-building, and the development of an inclusive digital ecosystem.

4.3. Challenges and Policy Implications for Slovakia

Regional policies face two fundamental challenges: coordination and governance. To achieve tangible results, regional policies must interplay and create synergy through the complex interaction of various policies. Furthermore, how various regional actors with diverse characteristics and objectives participate and interact within the regional economic ecosystem is crucial. Despite its small size, Slovakia's policy regime is fragmented. This contrasts sharply with the Korean model of central leadership. This challenge is particularly evident in the transition to a digital economy.

Table 3.
Comparison of Key Challenges in Slovakia's SME Digitalization and Korean Policy Implications

Slovak Challenges	Brief Description	Korean Case or Experience	Policy Implication
Lack of program readiness and delayed execution	Absence of manuals, unclear procedures, and delayed disbursement	Integrated SME support programs coordinated by KADO and the One Million SMEs Informatization Plan	Ensure pre-launch readiness with standardized manuals, trained staff, and integrated digital platforms under centralized governance
Low accessibility for micro-enterprises and rural firms	Complex application process, low digital literacy, limited consulting support	Government-dispatched informatization consulting teams under the One Million SMEs Plan, providing on-site diagnostics, modular IT support, and user training	Design user-friendly systems with embedded guidance and field support
Superficial or fragmented use of digital tools	Digital tools used for basic input only; limited integration	Smart Factory program with phased digital maturity levels	Support firms based on their digital maturity stage and integrated processes
Fragmented governance and overlapping responsibilities	Multiple agencies are involved, leading to confusion and inefficiencies	Dedicated implementing agencies for ICT grants (e.g., NIPA, KIAT)	Reduce fragmentation by centralizing administration and communication
Exclusion of the Bratislava region from funding eligibility	Most advanced region excluded due to EU regional aid rules	Special industrial zone programs that complemented regional rules	Develop differentiated regional instruments to complement EU constraints

Source: Author.

Structural and Regional Digital Divides

- Infrastructure Disparities: The unequal distribution of digital infrastructure is perhaps Slovakia's most salient structural challenge. Urban-rural divides in broadband access, with rural VHCN coverage at only 30%, create a two-tiered digital economy (European Commission, 2024). SMEs in rural areas are systematically disadvantaged, facing higher costs, reduced speeds, and limited access to digital public services (e-government, digital education, telehealth). This not only hinders business growth but also perpetuates regional economic disparities, thereby undermining the goal of achieving balanced national development.
- Socioeconomic and Educational Inequalities: Digital skills and access are closely correlated with socioeconomic status and educational attainment. OECD's PISA data reveal that socioeconomic status accounts for 26% of the variation in math scores among Slovak students—well above the OECD average (OECD, 2023). While not a direct measure of digital competence, this statistic highlights deep-rooted inequalities in access to quality education and, by extension, digital learning opportunities. These disparities are most pronounced among senior citizens, low-income groups, and rural populations, who are less likely to possess basic digital skills or benefit from digitalization initiatives.

Low Digital Adoption Among SMEs

- Reluctance and Capacity Constraints: Despite policy incentives, many Slovak SMEs—especially micro and small enterprises—remain hesitant to adopt digital tools. The barriers are multifaceted, including high upfront costs, a lack of internal expertise, uncertainty about the return on investment, and limited awareness of available support. Traditional sectors, which often form the backbone of regional economies, are particularly slow to adopt digitalization, further entrenching structural disadvantages.
- Limited Reach of Support Mechanisms: Government initiatives such as Digital Innovation Hubs have not sufficiently penetrated the most at-risk segments of the SME sector. Generic policy instruments often fail to address the specific needs of micro-enterprises or those operating in traditional sectors. As a result, the digital divide within the SME sector continues to widen, with digitally advanced firms pulling ahead and laggards falling further behind.

Governance and Policy Coordination Challenges

- Fragmented Policy Landscape: Slovakia's digitalization agenda suffers from overlapping responsibilities, administrative complexity, and a lack of clear accountability (MIRRI, 2021). Multiple agencies share jurisdiction over digital policy, leading to coordination failures and inefficiencies. The absence of a unified implementation framework undermines the effective delivery of support to SMEs and inhibits the scaling of successful initiatives.
- Insufficient On-Site and Localized Support: Existing support structures are often centralized and bureaucratic, making them inaccessible to SMEs in remote or underserved regions. There is a pressing need for decentralized, on-the-ground advisory services to provide tailored guidance and facilitate the adoption of digital solutions.

Sustainability of Funding and Institutional Support

- Dependence on EU Funding: Slovakia's digital transformation has been heavily subsidized by EU funds, particularly through the NRRP and the NextGenerationEU program. While these resources have been instrumental in catalyzing progress, their anticipated decline raises concerns about the long-term sustainability of digitalization efforts. Without robust domestic funding mechanisms and institutional capacity, there is a risk of policy discontinuity and stalled momentum.
- Early-Stage Public-Private Partnerships: Initial steps have been taken to foster public-private collaboration, but these efforts remain underdeveloped. Private sector engagement in digitalization projects and innovation networks is limited, and there is a need to scale up successful models and institutionalize partnership frameworks.

Workforce Digital Skills Gap

- Gaps in Basic and Advanced Digital Competencies: National statistics indicate that 55% of adults possess basic digital skills, but this figure obscures significant intra-country variation. Older adults, individuals with lower educational attainment, and residents of rural areas are disproportionately affected by digital exclusion. The integration of digital skills into mainstream education remains incomplete, and disparities in infrastructure and resources persist, particularly in under-resourced schools.
- Lifelong Learning and Upskilling Deficits: The rapidly evolving digital landscape demands continuous upskilling and reskilling. However, Slovakia's current training infrastructure is underdeveloped and does not adequately meet the needs of the existing workforce, especially in sectors most vulnerable to digital disruption.

4.4. Policy Implications

Due to differences in economic structure and conditions, it is difficult to transplant Korea's experience to Slovakia directly. However, lessons learned during policy implementation remain relevant today. Korea prioritized fostering a national ecosystem based on the activities of leading large corporations in the digital economy. Consequently, policy support was focused on SMEs and small businesses, which lagged and lacked capabilities. While there were some setbacks, the approach was overall effective.

Policies should be able to respond to environmental changes proactively. Now, the digital economy is facing a new technological wave of AI, data, and automation. The new wave demands a different approach to policy. In the past, policy goals focused on building physical infrastructure and promoting increased use. In today's virtual space, where everything is easily connected, the way economic value is created is also changing. The following are suggestions that are thought to be particularly important, in consideration of Korea's experiences in light of today's circumstances.

Table 4.
Key Challenges in Slovakia's SME Digitalization and Korean Policy Implications

Observed a Bottleneck in Slovakia	Korean Experience / Lesson	Implication for Slovakia
Fragmented Institutional Responsibilities	Strong central leadership: Presidential Council, NIA-led centralized planning and delivery	Ensure stable leadership by creating a permanent digital coordination body (e.g., inside MIRRI)
Missing Manuals and Unclear Procedures	Well-defined service delivery: multi-year plans, defined roles (planning vs. execution), standardized delivery protocols	Build a structured and transparent execution framework with defined agency roles and operational toolkits.
Rural Digital Infrastructure Gap	Regional informatization hubs and early investment in local broadband access	Build on and scale existing EDIHs to create regionally anchored digital hubs with stronger national integration, stable funding, and expanded outreach to rural micro-businesses
Low Digital Skills and SME Readiness	Layered consulting structure: public agencies, on-site experts, ASP providers, student volunteers	Use Korea's multi-actor, tiered approach to inform Slovakia's upcoming SME training and capacity-building policies (to be detailed in the final report)
Shallow and Fragmented Tool Adoption	Bundled policy design combining diagnostics, consulting, and follow-up incentives (e.g., DIGITRANS-style integration)	Institutionalize diagnostic-based digital support with pre-/post-assistance and simplified onboarding.

Source: Author.

Bridging Regional and Socioeconomic Divides

- Prioritize Rural and Underserved Regions: Invest in expanding broadband infrastructure and digital public services in rural areas, leveraging both public and private resources. Infrastructure expansion should be coupled with targeted outreach and support for rural SMEs to ensure equitable participation in the digital economy.
- Tailored Support for Vulnerable Groups: Develop specialized programs for micro-enterprises, traditional sectors, and disadvantaged populations. This should include subsidized access to digital tools, mentorship, and capacity-building initiatives designed to address specific barriers faced by these groups.

Enhancing SME Digital Adoption

- Sector-Specific and Hands-On Support: Move beyond one-size-fits-all policies by offering sector-specific advisory services, digital innovation hubs, and demonstration projects tailored to each sector. Facilitate peer learning and knowledge transfer among SMEs, and incentivize participation in digital ecosystems.
- Promote Collaborative Innovation: Foster partnerships among SMEs, large enterprises, research institutions, and technology providers to drive innovation and diffusion of digital solutions. Establish regional innovation clusters and networks to support collective learning and resource sharing.

Strengthening Governance and Implementation Frameworks

- Streamline Policy Coordination: Clarify roles and responsibilities across government agencies, establish a central coordinating body for digitalization, and implement robust monitoring and evaluation mechanisms to ensure effective coordination. Ensure that policy frameworks are adaptable and responsive to emerging challenges.
- Decentralized Support Structures: Establish regional and local digitalization advisory centers staffed with experts who can provide on-site assistance to SMEs. Empower local governments and community organizations to play a more active role in digital transformation.

Building Sustainable Funding and Institutional Capacity

- Develop Domestic Funding Mechanisms: Reduce reliance on EU funds by cultivating national and regional funding sources, including tax incentives, grants, and venture capital, to support digital innovation. Encourage private sector investment through co-financing schemes and risk-sharing arrangements.

- Institutionalize Public-Private Partnerships: Formalize and scale up successful PPP models, creating platforms for ongoing collaboration between government, industry, and academia. Leverage the expertise and resources of the private sector to accelerate digitalization across the SME ecosystem.

Closing the Digital Skills Gap

- Integrate Digital Skills Across the Education System: Embed digital literacy and advanced competencies into curricula at all educational levels. Provide training and resources to teachers to deliver effective digital education, ensuring equitable access to digital learning tools.
- Promote Lifelong Learning and Workforce Upskilling: Expand access to continuous training and certification programs for the existing workforce, with a focus on sectors and regions most at risk of digital exclusion. Incentivize SMEs to invest in employee upskilling and create pathways for career advancement in the digital economy.

5. A Strategy for Green Hydrogen Industry Development towards Balanced National Development: Focusing on Manufacturing Sector

This chapter explores how Slovakia can strategically develop a green hydrogen industry. It forms part of the 2024/25 KSP. The chapter aims to deliver actionable recommendations for building a robust hydrogen-based industrial ecosystem, with a focus on manufacturing development and bilateral cooperation with Korea.

The report is structured around two interrelated pillars:

- Hydrogen Industry Ecosystem Development: Examines how Slovakia can leverage its strong manufacturing base to foster a comprehensive hydrogen industry, drawing on Korea's advanced policy experience in materials, components, and equipment (MCE) localization
- Institutional and Bilateral Cooperation: Proposes mechanisms for practical Korea-Slovakia collaboration, including joint demonstration projects, policy alignment, and the establishment of supportive institutional frameworks

The overarching aim is to assist Slovakia in formulating a hydrogen transition strategy that is both ambitious and feasible, informed by Korea's policy, technology, and institutional experiences, and closely aligned with European Union (EU) climate and industrial policies.

5.1. Background

Slovakia-Korea: Common Grounds for Hydrogen Collaboration

Slovakia and Korea share several strategic characteristics that provide a strong foundation for hydrogen cooperation:

- Manufacturing-Based, Export-Oriented Economies: Manufacturing accounts for about 20.7% of Slovakia's GDP and 24.3% of Korea's (World Bank, n.d.-a; World Bank, n.d.-b; World Bank, n.d.-c; World Bank, n.d.-d). Both countries are deeply integrated into global value chains (GVCs), particularly in the automotive and electronics sectors, making them highly sensitive to global decarbonization trends and regulatory shifts.

- Export Profiles: Slovakia's exports are dominated by the automotive sector, with cars and related products accounting for nearly 39% of total exports (The Observatory of Economic Complexity [OEC], n.d.-b). In comparison, Korea's leading export category is electrical machinery and electronics (over 32%) (OEC, n.d.-a). Both countries also have significant shares in machinery, mineral fuels, and plastics (OEC, n.d.-a; OEC, n.d.-b).
- Energy and Carbon Challenges: Slovakia, while improving, still has a higher energy intensity than advanced economies (IEA, n.d.). Korea, although efficient in high-value-added sectors, faces emissions challenges in the steel, cement, and automotive manufacturing industries. Both are under pressure from international environmental regulations such as RE100 and the EU's Carbon Border Adjustment Mechanism (CBAM), necessitating proactive decarbonization strategies (European Commission, 2019b; European Commission, 2022; European Commission, 2019a; European Parliament and the Council, 2023).
- Industrial Complementarities: Slovakia is a significant European automotive hub, home to global brands such as Volkswagen, Kia, PSA, and Jaguar Land Rover. Korea has developed vertically integrated OEM models and is increasing self-sufficiency in industrial materials and manufacturing technologies (Government of Korea, 2023), especially through Hyundai and Kia. These complementarities create opportunities for joint value chain innovation in the hydrogen sector.

The study aims to support Slovakia in establishing a hydrogen transition strategy that reflects both long-term objectives and practical feasibility, drawing on lessons from Korea's experience in policy-making, technology development, and institutional design. The study is organized around:

- Industry Structure Analysis: Examining the hydrogen industry's structure and dynamics in both countries.
- Institutional Cooperation: Reviewing how public-private partnerships and policy platforms can facilitate the energy transition.
- Recommendations: Providing actionable, evidence-based recommendations suited to Slovakia's industrial needs and sustainability goals.

5.2. Building a Hydrogen Industry Ecosystem in Slovakia

European and Slovak Hydrogen Policy Framework

Slovakia's hydrogen strategy is heavily influenced by the EU's ambitious climate and energy policies:

- European Green Deal: The EU's overarching strategy for achieving carbon neutrality by 2050, emphasizing the decoupling of economic growth from resource use and the

decarbonization of key sectors, including industry, energy, and transport. Renewable hydrogen is identified as a strategic energy vector for deep decarbonization and industrial competitiveness (European Commission, 2019b).

- REPowerEU: Launched in response to the energy crisis, this initiative aims to produce or import 20 million tons of renewable hydrogen by 2030 and accelerate the deployment of electrolyzer capacity. It prioritizes replacing fossil fuels with renewable hydrogen in energy-intensive industries (European Commission, 2022; IEA, 2024).
- Renewable Energy Directive (RED III): Requires renewable hydrogen to account for at least 42% of industrial hydrogen use and 1% of energy in transport by 2030, rising to 60% for industry by 2035. Additional regulations, such as the Hydrogen and Decarbonized Gas Market Package, are establishing dedicated hydrogen networks and markets (European Parliament and the Council, 2024a, 2024b; European Parliament and the Council, 2023).
- EU Funding Instruments: The Innovation Fund (approximately EUR 40 billion by 2030) and the European Hydrogen Bank offer substantial financial support for hydrogen projects, incentivizing both supply and demand, and facilitating the integration of hydrogen into industrial and transportation applications (European Parliament, 2024; European Commission, 2023; European Parliament and the Council, 2021; European Commission, 2020; European Commission, 2019a; Clean Hydrogen Partnership, n.d.; NAFTA, 2022; NVAS, n.d.-a).

Slovakia's National Hydrogen Strategy and Goals

Slovakia's National Hydrogen Strategy (NHS), first adopted in 2021 and updated in 2023, aligns with the European Green Deal and Fit for 55 targets (Sinay *et al*., 2021; Sinay *et al*., 2023).

- The strategy recognizes hydrogen as an essential energy carrier for decarbonizing sectors where direct electrification is impractical or inefficient. NHS identifies several application areas, including chemicals, steel, natural gas, and transportation (Sinay *et al*., 2021).
- The strategy projects hydrogen demand of approximately 200,000 tons per year by 2030, potentially rising to 400,000–600,000 tons by 2050 under an intensive adoption scenario. By mid-century, 90% of this hydrogen is expected to be low-carbon or green (Sinay *et al*., 2021).
- For 2030, the strategy estimates that achieving meaningful hydrogen mobility deployment will require around EUR 2.4 billion in investment to deploy about 9,000 hydrogen passenger vehicles and 300 buses (International Trade Administration, 2023).

To implement this vision, the government developed an Action Plan detailing specific measures, timelines, and responsibilities (Sinay *et al*., 2023). An inter-ministerial working group on hydrogen coordinates policy and regulatory updates. By 2024, Slovakia aimed to introduce a supportive legislative framework by updating technical standards, streamlining permitting processes, and transposing EU rules (Sinay *et al*., 2023).

Slovakia's Regional Hydrogen Development

Slovakia is developing two main hydrogen hubs, with additional emerging players, despite its late entry, leveraging existing industrial assets and EU-supported projects.

- Košice Hydrogen Valley (Eastern Slovakia): The "EastGate H2V" project involves 22 partners across seven countries (Hydrogen Europe, 2025). Phase 1 (by mid-2027) includes a 2 MW electrolyzer producing 170 tons of green hydrogen annually for ten buses and cargo drones (Hydrogen Europe, 2025). Phase 2 doubles capacity to over 500 tons yearly with expanded fleets (Hydrogen Europe, 2025). Košice benefits from the Hydrogen Research Center, university collaboration (Halama *et al*., 2021), Slovakia's first hydrogen bus prototype in 2021, and proximity to large industrial emitters like U.S. Steel (U.S. Steel, 2022; U.S. Steel Košice, n.d.).
- Bratislava and Western Slovakia: Centered on the Slovnaft refinery, this region launched the country's first regular hydrogen bus service in 2023 (SLOVNAFT, 2023). The upgraded station now operates at 350 bar, increasing bus range by 40% (MOL Group, 2024). MOL Group plans to install a 10 MW electrolyzer at Slovnaft, capable of producing 1,600 tons of green hydrogen annually (MOL Group, 2024). Duslo Šaľa is seeking EUR 58 million in EU funding for renewable hydrogen production by 2030 (Spectator, 2024).
- Emerging Players: Slovak companies are entering. For example, NAFTA partnered with Germany's RWE for blue hydrogen (Burgess, 2021), Eustream plans 5% hydrogen blending in gas networks, and BCF Energy targets 40 refueling stations (International Trade Administration, 2023). Local innovation includes hydrogen bus prototypes (Spectator, 2021) and aircraft development through EU projects (TASR, 2024).

Korea's Hydrogen Policy Framework

Korea unveiled its Hydrogen Economy Roadmap in 2019 and has since developed one of the world's most comprehensive hydrogen policy frameworks (Government of Korea, 2019; MOTIE, 2019). Korea established dedicated legislation, governance structures, and market mechanisms to become a leading hydrogen economy by 2040.

- Hydrogen Economy Promotion and Safety Act (2020): Korea was among the first

countries to enact standalone hydrogen legislation (KLRI, 2020). The Hydrogen Act provides a comprehensive legal framework that covers safety standards, R&D subsidies, tax incentives, and mandates the development of regular Master Plans (Government of Korea, 2021). It established the Korea Gas Safety Corporation as the national hydrogen safety authority. It was amended in 2022 to include a Clean Hydrogen Certification system, which defines clean hydrogen as having lifecycle emissions of less than 4 kg CO_2 per kg H_2 (KLRI, 2022).

- Clean Hydrogen Portfolio Standard (CHPS): Korea introduced the world's first hydrogen-specific portfolio standard, requiring power producers to include clean hydrogen-based electricity in their generation mix (CMS, 2024). Launched alongside a 15-year contract bidding market in 2023, CHPS evaluates bidders on price and carbon intensity (MOTIE, 2024; KPX, 2024), creating guaranteed demand for low-carbon hydrogen and incentivizing the shift from grey to blue and green hydrogen.

Concerning governance structure, the Hydrogen Economy Committee, chaired by the Prime Minister with up to 20 members from ministries and experts, provides top-level coordination authority (KLRI, 2020). The Ministry of Trade, Industry and Energy (MOTIE) serves as the lead implementer, while other ministries handle sector-specific issues (CSIRO, n.d.).

Korea has pursued many implementation projects, with significant effects on local economies. Two cases are noticeable.

- Pohang Hydrogen Complex: Designated as one of Korea's first specialized hydrogen industrial complexes, scheduled for completion in 2028, focusing on hydrogen production, storage, and equipment manufacturing (Pohang City, 2024; Lee, 2024)
- Ulsan Hydrogen City: Led hydrogen town initiatives utilizing by-product hydrogen from local petrochemical operations, demonstrating integrated urban hydrogen systems for residential heating, power generation, and transportation (Ulsan Metropolitan City, 2024a, 2024b)

The Korean experiences, in designing policy frameworks and implementing projects in relation to local economies, provide a relevant and adaptable model for Slovakia:

- Industrial Clustering: Development of hydrogen-specialized complexes and clusters to foster innovation, achieve economies of scale, and support regional economic revitalization (MOTIE, 2021; MOLIT, 2024)
- Public-Private Partnerships: Strong collaboration among government, industry, and academia to accelerate R&D, commercialization, and market creation (Government of Korea, 2023; H2KOREA, n.d.)
- Localization of MCE: Strategic focus on localizing the manufacturing of hydrogen

materials, components, and equipment, to enhance supply chain resilience and technological self-sufficiency (Government of Korea, 2023; KIAT, n.d.)

- Policy Tools: Application of regulatory incentives, tax benefits, and targeted support for hydrogen R&D and commercialization (CMS, 2024; KOTRA, 2024; Jo, 2021), along with the establishment of demonstration projects and pilot programs

Challenges Facing Slovakia and Policy Recommendations

Despite clear momentum, Slovakia faces significant challenges in building a full-fledged hydrogen industry ecosystem, particularly in scaling up from pilot projects to mass deployment and local manufacturing:

- Funding Shortfalls: Current EU funding is insufficient to meet 2030 goals. Only three refueling stations are funded through 2026, when dozens are needed, and Slovakia has just a handful of hydrogen vehicles despite projecting 9,000 by 2030 (International Trade Administration, 2023).
- Missing Supply Chain: Slovakia lacks domestic manufacturers of electrolyzers and hydrogen components, forcing expensive imports and limiting local job creation. Slovakia aims to develop its indigenous manufacturing through European partnerships, but this requires establishing a stable domestic market first (NVAS, n.d.-b; Hydrogen Europe, 2025).
- Infrastructure Gaps: Slovakia needs updated pipelines, storage facilities, safety regulations, and expanded renewable electricity capacity to support large-scale hydrogen production and distribution (Sinay *et al*., 2023; Spectator, 2024).
- Commercial Viability: Most current projects are heavily subsidized demonstrations rather than commercially sustainable operations. Success requires long-term contracts between producers and users, as well as consistent government policy to attract substantial private investment (Sinay *et al*., 2021).

With these difficulties, Slovakia has rapidly progressed from no hydrogen activity to multiple strategic projects, building on its automotive and engineering expertise as a foundation for future hydrogen manufacturing.

The chapter suggests that Slovakia:

- Develop a Hydrogen Ecosystem: Rooted in its manufacturing strengths, Slovakia should localize hydrogen technologies (fuel cells, electrolyzers, storage systems) and encourage participation from SMEs and large manufacturers
- Promote Technology Transfer and R&D: Facilitate collaboration with international partners, particularly those from Korea, to accelerate innovation and workforce development

- Align Policies with EU Directives: Ensure coherence with EU frameworks and maximize access to funding instruments, such as the Innovation Fund and the European Hydrogen Bank (European Parliament, 2024; European Commission, 2023; European Investment Bank, n.d.)

5.3. Korea-Slovakia Hydrogen Cooperation Strategy

The strategy consists of two main focus areas. The first is to create conditions that support joint efforts in hydrogen-related manufacturing, and the second is to develop concrete implementation mechanisms. The goal is to move from shared vision to collaborative action through step-by-step initiatives that align with the needs of both countries.

Manufacturing Sector Cooperation

The report proposes a multi-layered cooperation strategy

- Joint Demonstration Projects: In hydrogen mobility, industrial applications, and infrastructure, leveraging Korea's technological strengths and Slovakia's manufacturing base
- Policy Dialogue and Knowledge Sharing: Establishing platforms for exchanging best practices and fostering strategic alignment
- Workforce Development: Joint training programs to address talent gaps in the hydrogen sector
- Industrial Clustering: The creation of hydrogen clusters in Slovakia, modeled after Korea's experience, aims to drive regional innovation and economic revitalization

Implementation Framework

A phased, adaptive approach is recommended, with clear milestones and strategies in place to accommodate technological and market changes, thereby ensuring long-term sustainability and competitiveness.

5.4. Policy Recommendations

By comparing the approaches of the two countries, lessons beneficial for future cooperation can be presented as follows. The key message is that Slovakia's early efforts to develop hydrogen and Korea's advanced policy and industrial framework provide a strong foundation for cooperation. The recommendations aim to facilitate the bilateral cooperation that can support faster hydrogen introduction and provide shared economic value.

- Strategic Importance of Hydrogen: Green hydrogen serves as a lever for both decarbonization and balanced national development, enabling the creation of new value chains and revitalizing traditional manufacturing sectors.
- Manufacturing-Centric Approach: Slovakia's manufacturing base, particularly in the automotive sector, provides a strong foundation for the growth of the hydrogen industry, especially when combined with Korea's policy and industrial expertise.
- Institutional and Policy Innovation: Public-private partnerships, industrial clusters, and adaptive regulatory frameworks are critical for success.

Strategic Recommendations

- Build a Comprehensive Hydrogen Ecosystem: Anchored in manufacturing and supported by technology transfer and R&D partnerships
- Harmonize National Policies with EU Frameworks: Maximize use of EU funding and regulatory incentives
- Institutionalize Korea-Slovakia Cooperation: Through joint projects, policy platforms, and workforce development initiatives
- Foster Regional Hydrogen Clusters: To promote innovation, economic growth, and balanced national development
- Adopt a Phased, Adaptive Approach: With clear milestones for 2030 and beyond, allowing for continuous learning and adjustment

Implementation Roadmap

To ensure effective execution of these recommendations, we propose a phased implementation roadmap:

- Short-Term (2025–2027): Establish a national hydrogen task force, launch pilot projects, and initiate joint research and training programs
- Medium-Term (2028–2030): Expand hydrogen clusters, deepen Korea-Slovakia partnerships, and integrate hydrogen into core industries

- Long-Term (Post–2030): Achieve national hydrogen targets, position Slovakia as a regional leader, and foster continuous innovation

Table 5.
A Phased Bilateral Cooperation Agenda (2025-2035)

Phase	Timeline	Key Activities
Foundation	2025-2027	- Align standards and certification (MOTIE-SIEA joint group) - Launch joint feasibility studies
Demonstration and Localization	2027-2029	- Pilot joint manufacturing (licensing of Korea's components to Slovak suppliers) - Open co-branded refueling stations - Establish pilot training programs
Commercial Scale-Up	2030+	- Launch commercial pilot manufacturing and DRI production - Exchange infrastructure knowledge (with KOGAS support) - Develop a joint curriculum and implement researcher exchange programs

Source: Author.

References

Policy, Strategy, and Institutional Reports

Digital Coalition. "The National Digital Skills Strategy of the Slovak Republic and the Action Plan for the Years 2023–2026." Bratislava: Digital Coalition, 2023.

European Commission, "Commission Staff Working Document: Impact Assessment Accompanying the document Commission Delegated Regulation Supplementing Directive 2003/87/EC of the European Parliament and of the Council with regard to the operation of the Innovation Fund", SWD (2019) 85 final, February 26, 2019a (accessed September 25, 2025).

_____, Communication from the Commission: The European Green Deal, COM (2019) 640 final, December 11, 2019b (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640, accessed September 25, 2025).

_____, Implementation Strategy for Horizon Europe, Version 1.0, April 29, 2020 (accessed September 25, 2025).

_____, Communication from the Commission: REPowerEU Plan, COM (2022) 230 final, May 18, 2022 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0230, accessed September 25, 2025).

_____, A Green Deal Industrial Plan for the Net-Zero Age, Communication from the Commission COM (2023) 156 final, March 16, 2023 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023DC0156, accessed September 25, 2025).

_____, "Slovakia's Recovery and Resilience – Supported Projects: Nation-wide Investment Scheme," February 2024 (https://commission.europa.eu/business-economy-euro/ economic-recovery/recovery-and-resilience-facility/country-pages/slovakias-recovery-and-resilience-plan_en, accessed April 4, 2025).

_____. Digital Decade 2024: Broadband Coverage in Europe 2023. Luxembourg: Publications Office of the European Union, 2024.

European Parliament. Recovery and Resilience Plans – Slovakia, Briefing, Feb 2022. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733642

_____, European Parliament Resolution of 18 January 2024 on the Implementation of the REPowerEU Plan (2023/2008(INI)), 2024/C 104/15, January 18, 2024 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023IP0484, accessed September 25, 2025).

European Parliament and the Council, Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 Establishing Horizon Europe – the Framework Programme for Research and Innovation, and Repealing Regulations (EU) No 1291/2013 and (EU) No 1290/2013, April 28, 2021 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0695, accessed September 25, 2025).

_____, Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as Regards the Promotion of Energy from Renewable Sources, and Repealing Council Directive (EU) 2015/652, October 18, 2023 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:

32023L2413, accessed September 25, 2025).

_____, Directive (EU) 2024/1278 of the European Parliament and of the Council of 24 April 2024 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive (EU) 98/70/EC as Regards the Promotion of Energy from Renewable Sources, and Repealing Council Directive (EU) 2015/652, April 24, 2024a (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_2024 01788, accessed September 25, 2025).

_____, Regulation (EU) 2024/1279 of the European Parliament and of the Council of 24 April 2024 on the Internal Markets for Renewable Gases, Natural Gas and Hydrogen, and Amending Regulations (EC) No 715/2009, (EU) 2017/1938 and (EU) 2018/1999, and Repealing Regulation (EU) 715/2009, April 24, 2024b (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_2024 01789, accessed September 25, 2025).

Government of Korea, *수소경제 활성화 로드맵* [Hydrogen Economy Activation Roadmap], January 2019. [in Korean]

_____, *제1차 수소경제 이행 기본계획* [The First National Basic Plan for Implementing the Hydrogen Economy], November 26, 2021. [in Korean]

_____, *수소산업 소부장 육성 전략* [Hydrogen Industry Strategy for Materials, Components, and Equipment Development], December 18, 2023. [in Korean]

Halama, Maroš, et al., Hydrogen Strategy for the Košice Region: The First Hydrogen Strategy in Slovakia, Technical University in Košice and Košice Self-Governing Region, 2021.

Hwang, S.-H., and I.-K. Park, *캠퍼스 혁신파크 사업 현황과 산업단지 시사점* [Current Status of the Campus Innovation Park Project and Implications for Industrial Complexes], Industrial Location Trend and Issue, no. 23: 1–12, 2021. [in Korean]

Joint Ministerial Press Releases, “Measures to Enhance the Effectiveness of Human Resource Development for University–Industry Cooperation,” December 17, 2020.

KIAT, *신성장·원천기술 세액공제 시스템* [Tax Credit System for New Growth-Core Technologies], https://taxcredit.kiat.or.kr/front/user/main.do#, accessed April 30, 2025, n.d. [in Korean]

Korea Legislation Research Institute (KLRI), *수소경제 육성 및 수소 안전관리에 관한 법률* [Hydrogen Economy Promotion and Hydrogen Safety Management Act], February 4, 2020 (https://elaw.klri.re.kr/eng_service/lawView.do?hseq=54651&lang=ENG, accessed June 1, 2025). [in Korean]

_____, *수소경제 육성 및 수소 안전관리에 관한 법률 개정* [Amendment to Hydrogen Economy Promotion and Hydrogen Safety Management Act], June 10, 2022 (https://elaw.klri.re.kr/kor_service/lawViewContent.do?hseq=60917, accessed June 1, 2025). [in Korean]

Ministry of Investments, Regional Development and Informatization of the Slovak Republic (MIRRI). Research and Innovation Strategy for Smart Specialisation of the Slovak Republic 2021–2027. Bratislava: MIRRI, 2021.

Ministry of Land, Infrastructure, and Transport of Korea (MOLIT), *수소특화단지 지정 및 지원방안* [Designation and Support Plan for Hydrogen-Specialized Complexes], March 10, 2024. [in Korean]

Ministry of Science and ICT, "한국과학기술 50년사: 제2편 과학기술 정책사 [50 Years of Science and Technology in Korea: Part II – Evolution of Science and Technology Policy and Administration]," 2017. [in Korean]

Ministry of Trade, Industry, and Energy of Korea (MOTIE), *수소경제 활성화 로드맵* [Hydrogen Economy Roadmap of Korea], January 17, 2019. [in Korean]

_____, "*수소 클러스터 구축사업, 예비타당성조사 대상사업으로 선정* [Hydrogen Cluster Development Project Selected for Preliminary Feasibility Study]," press release, August 24, 2021. [in Korean]

_____, "*세계 최초 청정수소발전 입찰시장 개설* [Launch of the World's First Clean Hydrogen Power Bidding Market]," https://www.korea.kr/briefing/pressReleaseView.do?newsId=156632411, accessed April 30, 2025, 2024. [in Korean]

OECD. PISA 2022 Results (Volume I): The State of Learning and Equity in Education. Paris: OECD Publishing, 2023.

_____, OECD Regions and Cities at a Glance 2024, Paris: OECD Publishing, 2024.

Sinay, et al., National Hydrogen Strategy: Ready for the Future, Ministry of Economy of the Slovak Republic, 2021.

_____, Action Plan of the National Hydrogen Strategy, Ministry of Economy of the Slovak Republic, 2023.

Slovak Alliance for Innovation Economy. Digital Transformation of Slovak Micro, Small and Medium-sized Enterprises. Bratislava: SAPIE, 2023.

Ulsan Metropolitan City, "*울산시, 국토부 주관 '수소도시 조성사업' 공모 선정* [Ulsan Selected for the MOLIT-led Hydrogen City Development Project]," press release, September 20, 2024a (https://www.ulsan.go.kr/u/rep/bbs/view.do?bbsId=BBS_0000000000000027&mId=001004003001000000&dataId=165698, accessed April 30, 2025). [in Korean]

_____, "울산시, 전국 최초 수소시범도시 조성사업 준공 [Ulsan Completes Korea's First Hydrogen Pilot City Project]," press release, October 25, 2024b, (https://www.ulsan.go.kr/u/rep/bbs/view.do?bbsId=BBS_0000000000000027&mId=0010040030010000000&dataId=166392, accessed April 30, 2025). [in Korean]

Academic and Research Publications

Fadic, M., J. Garcilazo, A. Moreno Monroy, and P. Veneri, "Classifying Small (TL3) Regions Based on Metropolitan Population, Low Density and Remoteness," *OECD Regional Development Working Papers, no. 2019/06*, OECD Publishing, Paris, 2019.

Garcilazo, E., A. I. Moreno-Monroy, and J. Oliveira Martins, "Regional Inequalities and Contributions to Aggregate Growth in the 2000s: An EU vs US Comparison Based on Functional Regions," *Oxford Review of Economic Policy 37 (1): 70–96*, 2021.

Hrivnák, M., and J. Jarábková, "Drivers of Academic Engagement and University–Industry Collaboration in Conditions of Slovakia," *Administrative Sciences 12 (128)*, https://doi.org/10.3390/admsci12040128, 2022.

Lešková, A., and M. Šipikal, "Higher Education Institutions Performance in Convergence Regions After the EU Enlargement: Case of Slovakia," *Ekonomický Časopis 67 (7): 743–760*, 2019.

Rehák, S., M. Šipikal, and A. Lešková, "Evolution of University Third Mission Activities in Slovakia: What Role for a Public Policy?" *Quality Innovation Prosperity (Kvalita Inovácia Prosperita) 23 (1): 119–135*, 2019.

Industry, Media, and Online Sources

Burgess, James. 2021. "Gas groups sign blue hydrogen MOU in Slovakia." S&P Global. September 24, 2021. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/electric-power/092421-gas-groups-sign-blue-hydrogen-mou-in-slovakia. Accessed on Jun. 2, 2025.

Clean Hydrogen Partnership, https://www.clean-hydrogen.europa.eu/index_en, accessed April 4, 2025, n.d.

CMS, "Hydrogen Law, Regulations & Strategy in South Korea," November 21, 2024, https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea, accessed June 2, 2025, 2024.

CSIRO, Republic of Korea (South Korea), https://www.csiro.au/, accessed June 2, 2025, n.d.

European Investment Bank, "Innovation Fund – Project Development Assistance," https://www.eib.org/en/products/mandates-partnerships/innovation-fund/index, accessed April 4, 2025, n.d.

Hydrogen Europe, "The First Hydrogen Valley to Be Built in Košice Region," April 11, 2025, https://hydrogeneurope.eu/the-first-hydrogen-valley-to-be-built-in-kosice-region/, accessed June 2, 2025, 2025.

H2KOREA, "Support for the Hydrogen Companies," https://h2korea.or.kr/en/business/page02_01, accessed June 2, 2025, n.d.

H2NEWS, "*수소기업에 특별함을 더하는 '수소특화단지'* [Empowering Hydrogen Companies through Specialized Industrial Complexes]," H2NEWS, November 21, 2024, https://www.h2news.kr/news/articleView.html?idxno=13094, accessed April 30, 2025, 2024. [in Korean]

International Energy Agency (IEA), "RePowerEU Plan: Joint European Action on Gas Supply Security," January 30, 2024, https://www.iea.org/policies/15688-repowereu-plan-joint-european-action-on-gas-supply-security, accessed April 30, 2025, 2024.

_____, "Energy Intensity by Sector – Slovakia," IEA Statistics, https://www.iea.org/data-and-statistics, accessed March 31, 2025, n.d.

International Trade Administration, "Slovakia Clean Energy Hydrogen in Automotive Industry," October 25, 2023, https://www.trade.gov/market-intelligence/slovakia-clean-energy-hydrogen - automotive-industry, accessed May 31, 2025, 2023.

Korea Power Exchange (KPX), "Clean Hydrogen Power Bidding System," https://www.kpx.or.kr, accessed April 30, 2025, 2024.

KOTRA, "Korea Setting Its Eyes on Creating a Clean Hydrogen Market," May 9, 2024, https://www.investkorea.org/ik-en/bbs/i-308/detail.do?ntt_sn=490795, accessed June 1, 2025, 2024.

MOL Group, "MOL Started Production in the Largest Capacity Green Hydrogen Plant of the Region," September 4, 2024, https://molgroup.info/en/media-centre/press-releases/mol-started-production-in-the-largest-capacity-green-hydrogen-plant-of-the-region, accessed April 30, 2025, 2024.

NAFTA, "First Important Project of Common European Interest in Hydrogen Technology Approved by the European Commission Comes from NAFTA," July 19, 2022, https://www.nafta.sk/en/news/first-important-project-common-european-interest-hydrogen-technology-approved-european, accessed June 2, 2025, 2022.

NVAS, "TOMARK PROTON Officially Launched the Implementation of the H2 VTOL Project," https://nvas.sk/en/tomark-proton-oficialne-zahajil-implementaciu-projektu-h2-vtol-10799/, accessed May 31, 2025, n.d.-a.

_____, “About Hydrogen,” https://nvas.sk/en/o-vodiku/, accessed June 2, 2025, n.d.-b.

Pohang City, “*포항시, 국내 최초 수소특화단지 지정 … K-수소경제 중심지로 도약* [Pohang Designated as Korea’s First Hydrogen Specialized Complex — Aiming to Become the Hub of the K-Hydrogen Economy],” November 1, 2024, https://www.pohang.go.kr/news/board/post/view.do?bcIdx=644&mid=0102000000&idx=1005694, accessed April 30, 2025, 2024. [in Korean]

SLOVNAFT, a.s., “Hydrogen Buses Run on Hydrogen from Slovnaft on Bratislava's Roads,” August 18, 2023, Plasticportal, https://www.plasticportal.eu/articles/hydrogen-buses-run-on-hydrogen-from-slovnaft-on-bratislavas-roads, accessed May 31, 2025, 2023.

Spectator, “First Slovak Hydrogen Bus Comes from Eastern Slovakia,” August 6, 2021, https://spectator.sme.sk/business/c/first-slovak-hydrogen-bus-comes-from-eastern-slovakia, accessed June 1, 2025, 2021.

_____, “Slovak Chemical Company to Produce Green Hydrogen,” January 10, 2024, https://spectator.sme.sk/business/c/slovak-chemical-company-to-produce-green-hydrogen, accessed May 31, 2025, 2024.

TASR, “Vodík do dopravy: EÚ schválila megainvestíciu do čistej energie a mobility, Slovensko je súčasťou” [Hydrogen for Transport: EU Approves Mega-Investment in Clean Energy and Mobility, Slovakia Is Part of It], Živé.sk, May 29, 2024, https://zive.aktuality.sk/clanok/P9Ytoil/vodik-do-dopravy-eu-schvalila-megainvesticiu-do-cistej-energie-a-mobility-slovensko-je-sucastou/, accessed May 31, 2025, 2024.

The Observatory of Economic Complexity, “Republic of Korea: Top Export Products (2023),” OEC – MIT Media Lab, https://oec.world/en/profile/country/kor, accessed March 31, 2025, n.d.-a.

_____, “Slovakia: Top Export Products (2023),” OEC – MIT Media Lab, https://oec.world/en/profile/country/svk, accessed March 31, 2025, n.d.-b.

U.S. Steel, 2021 Sustainability Report, March 2022, 2022.

U.S. Steel Košice, https://www.usske.sk/, accessed May 31, 2025, n.d.

World Bank, “Agriculture, Forestry, and Fishing, Value Added (% of GDP) – Slovak Republic, Korea, Rep.,” World Development Indicators, https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=SK-KR, accessed May 13, 2025, n.d.-a.

_____, “Industry (Including Construction), Value Added (% of GDP) – Slovak Republic, Korea, Rep.,” World Development Indicators, https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=SK-KR, accessed May 13, 2025, n.d.-b.

_____, “Manufacturing, Value Added (% of GDP) – Slovak Republic, Korea, Rep.,” World Development Indicators, https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=SK-KR, accessed May 13, 2025, n.d.-c.

_____, “Services, Value Added (% of GDP) – Slovak Republic, Korea, Rep.,” World Development Indicators, https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS?locations=SK-KR, accessed May 13, 2025, n.d.-d.

Yonhap News Agency, “*현대차SK·포스코·한화 효성, 수소경제에 43조원 투자* [Hyundai Motor, SK, POSCO, Hanwha, and Hyosung to Invest 43 Trillion KRW in the Hydrogen Economy],” Yonhap News Agency, March 2, 2021, https://www.yna.co.kr/view/AKR20210302090200003, accessed June 2, 2025, 2021. [in Korean]

Related Materials

Korea Development Institute (KDI), "Enhancing SME Support Linked to Industry 4.0 in Slovakia," *2022/23 KSP Policy Consultation Report*, KDI, 2023.

_____, "Networking as a Lever for Improving Innovation Ecosystem of Slovakia," *2023/24 KSP Policy Brief*, KDI, 2024.

_____, "Innovative Industrial Development and Balanced Regional Growth Strategy for Slovakia." *2024/25 KSP Policy Consultation Report (Online Publication)*, KDI, forthcoming.

2024/25 Knowledge Sharing Program

This publication summarizes the key findings of the Knowledge Sharing Program (KSP), funded by the Ministry of Economy and Finance (MOEF) of the Republic of Korea. The views expressed are those of the authors.

The KSP is a policy-oriented development cooperation program designed to share Korea's development experience and knowledge. Its goal is to support the institutional and capacity building of partner countries through collaborative research, policy consultations, and technical assistance on key policy issues.

For more information:
https://www.ksp.go.kr

Ministry of Economy and Finance (MOEF)
Sejong Government Complex, 42, Doum 6-ro, Sejong-si 30112, Republic of Korea
Tel. 82-44-215-7742
www.moef.go.kr

Korea Development Institute (KDI)
263, Namsejong-ro, Sejong-si 30149, Republic of Korea
Tel. 82-44-550-4114
www.kdi.re.kr

Knowledge Sharing Program (KSP)
www.ksp.go.kr

94320
9 791175 660120
ISBN 979-11-7566-012-0
ISBN 979-11-5932-110-8 (set)