



Ankara Chamber of Industry

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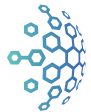
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TECHNOLOGICAL DEVELOPMENT INDEX OF PROVINCES

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Ankara Chamber of Industry



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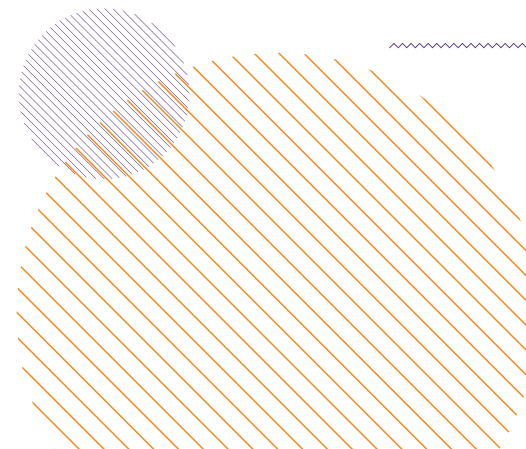
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ABBREVIATIONS



EU	: European Union
USA	: United States of America
AID	: Agence de l'Innovation de Défense (French Defense Innovation Agency)
R&D	: Research and Development
ASELSAN	: Military Electronics Industry
ASFAT	: Military Factory and Shipyard Management Inc.
ASO	: Ankara Chamber of Industry
ASO-İLTEK	: Ankara Chamber of Industry Technological Development Index of Provinces
BTK	: Information Technologies and Communications Authority
C4ISR	: Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CET	: Critical and Emerging Technologies
COVID-19	: Coronavirus Disease 2019
DAPA	: Defense Acquisition Program Administration (Republic of Korea)
DARPA	: US Defense Advanced Research Projects Agency
DASA	: UK Defense and Security Accelerator
DIANA	: Defense Innovation Accelerator for the North Atlantic
DIU	: Defense Innovation Unit
ECB	: European Central Bank
EDF	: European Defense Fund
G20	: Group 20 (World's 20 Largest Economies)
GII	: Global Innovation Index
GPS	: Global Positioning System

GDP	: Gross Domestic Product
HAI	: Stanford University Human-Centered AI Institute
IEA	: International Energy Agency
IMF	: International Monetary Fund
IoT	: Internet of Things
IRENA	: International Renewable Energy Agency
UAV	: Unmanned Aerial Vehicle
SME	: Small and Medium-Sized Enterprises
LLM	: Large Language Models
LNG	: Liquefied Natural Gas
MCF	: Military-Civil Fusion
MCP	: Model Context Protocol
MEMS	: Micro-Electromechanical Systems
MFP	: Multi-Factor Productivity
MKE	: Machinery and Chemical Industry
MÜSİAD	: Independent Industrialists and Businessmen Association





NATO : North Atlantic Treaty Organization
NIF : NATO Innovation Fund
NZIA : Net-Zero Industry Act
METU : Middle East Technical University
OECD : Organization for Economic Cooperation and Development
OIZ : Organized Industrial Zone
PCT : Patent Cooperation Treaty
ROKETSAN : Rocket Industry and Trade Inc.
PPP : Purchasing Power Parity
SIPRI : Stockholm International Peace Research Institute
UCAV : Unmanned Combat Aerial Vehicle
SSB : Presidency of the Republic of Türkiye Defense Industry
STEM : Science, Technology, Engineering, Mathematics
TAI : Turkish Aerospace Industries

TIM : Turkish Exporters Assembly
TOGG : Turkish Automobile Initiative Group
TSMC : Taiwan Semiconductor Manufacturing Company
TUSAŞ : Turkish Aerospace Industries Inc.
TÜBİTAK : Scientific and Technological Research Council of Türkiye
TÜİK : Turkish Statistical Institute
UN DESA : United Nations Economic and Social Affairs Office
UNCTAD : United Nations Conference on Trade and Development
P&D : Product and Development
VC : Venture Capital
WEF : World Economic Forum
WIPO : World Intellectual Property Organization
WTO : World Trade Organization
CAGR : Compound Annual Growth Rate
HT : High Technology
AI : Artificial Intelligence





PREFACE



Seyit ARDIÇ

Ankara Chamber of Industry
Chairman of the Board

The Ankara Chamber of Industry (ASO) transforms the strength and experience gained from its more than 62-year-long history into a strategic vision that guides the development of the capital's industry. Through our innovative projects, high-quality research, and sector-focused studies, we continue to play an active role in positioning Ankara as an industrial, technological, and defense hub not only for the region but for Türkiye as a whole. Our vision is; to transform Ankara into a highly competitive manufacturing hub that produces high technology and plays an active role in global value chains. In this context, our Chamber supports our companies in adapting to digital, green and social transformation processes and leads the creation of an innovative, sustainable and high value-added ecosystem.

As the Ankara Chamber of Industry, we attach importance to being a reliable point of reference in planning and policy-making processes and providing economic actors with a robust data and information infrastructure through our analyses that reveal national trends, risks and opportunities. In this era of reshaping global competition, the multiplier effect of defense industry technologies spreading across all sectors, along with the rise of artificial intelligence and advanced manufacturing techniques, creates a strategic window of opportunity for Türkiye. In this context, the Technological Development Index of Provinces (ASO-İLTEK) study which we are conducting for the second time this year, serves as an important roadmap shedding light on our sustainable development goals.

ASO-İLTEK studies seek to evaluate the technology production capacity of our provinces from a holistic perspective, to make their strengths and weaknesses visible and to provide evidence-based contributions to policy processes. This year's results show that Türkiye has gained significant momentum in its technology production capabilities but this momentum is not homogeneously distributed across the country. While Ankara and Istanbul continue their leading role in the high-tech ecosystem, strengthening

digital infrastructure, developing a qualified workforce and expanding R&D investments are critically important for other provinces to strongly integrate into this transformation.

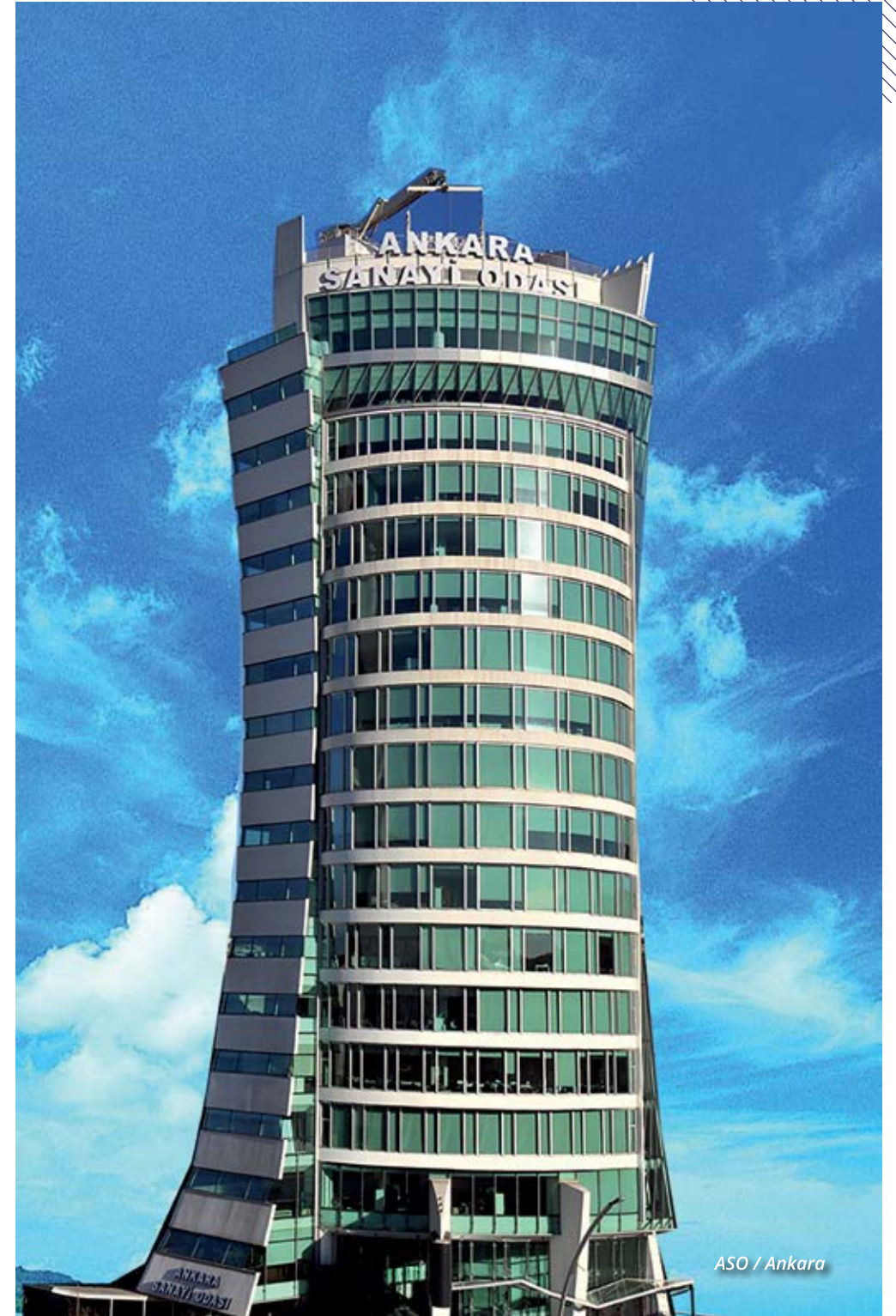
The findings presented by ASO-İLTEK this year indicate that Türkiye has gained significant momentum in technology production; however, capacity differences between provinces are still evident. These results clearly demonstrate the need for focused policy steps in many areas, from digital infrastructure and skilled workforce to R&D investments and the entrepreneurship ecosystem. The recommendations in the report present a holistic roadmap aimed at strengthening local ecosystems, deepening technological capabilities and creating a broader sphere of influence in strategic sectors, particularly the defense industry.

In this context, the defense industry stands out as a special theme in the Report, strikingly demonstrating the level of Türkiye's technology production capacity. Successes in defense create a powerful technology multiplier that triggers the development of many fields such as advanced materials, artificial intelligence, software, electronics and space technologies. Ankara's strategic role in this area is a concrete indication that our country has become an important center

for high-tech production. Transferring this accumulated expertise to sectors outside of defense is one of the key factors that will determine Türkiye's long-term competitiveness.

As the Ankara Chamber of Industry, we will resolutely continue to guide our members on their transformation journey, enhance their competencies in critical technologies and further deepen the strong ties that Ankara has established with technology centers. I believe that the findings presented in the second year of the ASO-İLTEK Report will make valuable contributions to shaping our national development strategies and strengthening local ecosystems.

I would like to express my sincere gratitude to our Chamber's Secretary General and ASO Technopark Inc. General Manager, Prof. Dr. Mehmet Cansız, who spearheaded this valuable work and worked with dedication at every stage, from the idea phase to its implementation and completion; to ASO Deputy Secretary General and ASO Technopark Inc. Deputy General Manager, Dr. Ahmet Dinçer; to our Entrepreneurship and Innovation Manager, Ms. Seda Aydın; and to all ASO employees and academics who contributed to this project.



ASO / Ankara

EXECUTIVE SUMMARY

The second edition of the Technological Development Index of Provinces (ASO-İLTEK), prepared by the Ankara Chamber of Industry, is designed to assess the level of technological development in Türkiye at the provincial level using a holistic and data-driven approach. Beyond simply measuring provinces numerically, ASO-İLTEK aims to make visible the spatial distribution of technological capabilities, identify areas of strength and potential for development and provide a strategic reference framework for policy-making processes. Unlike last year, a comprehensive thematic analysis has been added to the ASO-İLTEK 2025 content, aiming to contribute to contemporary discussions. This year's thematic focus area is defense industry technologies. This choice stems from the need to more deeply analyze the critical role of the defense industry in Türkiye's high-technology production and the potential for disseminating this expertise to the civilian economy.

Global Outlook: A New Equilibrium and Transformations

The global economy is undergoing a challenging period of rebalancing, overshadowed by deepening geopolitical rifts alongside digitalization, the green transformation and the artificial intelligence revolution. Geo-economic fragmentation which began with regionalization and increasing protectionist tendencies are transforming every aspect, from production structures to trade policies and investment decisions; technological competence is becoming the sole guarantee of national security and economic independence. On the other hand, the digital and green transformation is the main driving force initiating radical changes in production technologies, energy systems and the labor market. While 5G and increased computing capacity have enabled widespread use of artificial intelligence, the sharp decline in renewable energy costs has made electric vehicles and energy storage solutions highly competitive. Furthermore, inequalities in digital skills and AI competencies have become a limiting factor in the pace of transformation, especially for developing countries. In this context, digital and green transformation, beyond technological progress, has emerged as one of the key determinants of global competitiveness and economic security.

Convergence in critical technologies enables artificial intelligence, biotechnology, advanced materials, spatial intelligence and new energy technologies to advance in a mutually reinforcing ecosystem. This convergence is fundamentally transforming the production and competition structure, increasing the importance of strategies that



“Ankara, serving as the hub of technology production, and Istanbul, serving as the hub of global commercialization, together constitute the backbone of Türkiye's high-technology capacity.”

ASO Teknopark / Ankara

A Look at Türkiye in the Context of New Industrial Policies

prioritize economies of scale and standardization.

As a result of current global trends, industrial policies have once again gained a central position on a global scale and have diverged significantly from the previous approach in terms of scope, scale and function. Geo-economic fragmentation which accelerated especially after the pandemic accompanied by rapid price drops in critical technologies, increasing supply chain vulnerabilities and the high financing requirements of the green transition have made interventionist industrial policies a necessity, not a choice.

In this new era, industrial policy has transformed from a narrow tool aimed at increasing competitiveness in specific sectors into a multi-dimensional policy framework that simultaneously aims for strategic autonomy, technological sovereignty, supply chain security and the development of the necessary infrastructure for twin transformations. Accordingly, global actors -the US, the EU and China- aim to increase production capacity and competence in strategic technologies and sectors and strengthen supply security through various policy tools.

Within this overall picture, Türkiye ranks 43rd out of 139 countries in the Global Innovation Index and although it has dropped a few places compared to previous years, it maintains

its position as the third most innovative country among upper-middle-income economies, after China and Malaysia.

While Türkiye demonstrates strong performance, particularly in the production of creative outputs and commercially viable innovations, a significant capacity gap exists with leading countries in the artificial intelligence ecosystem. According to OECD data, the fact that AI skills are concentrated in high-income countries reveals that Türkiye is not alone among the countries facing both a shortage of qualified AI talent and a talent drain. In this framework, it is strategically important in the coming period for Türkiye to transform its innovation performance into a lasting competitive advantage, strengthening its AI capabilities, data and R&D infrastructure and human resources.

Throughout this transformation process, Türkiye stands out as a key player, particularly through its innovation outputs and capabilities focused on the defense industry. However, structural deficiencies in areas such as digital infrastructure, data center capacity and high-technology intensive manufacturing are hindering Türkiye's rapid convergence with developed economies. To accelerate and deepen the convergence process, Türkiye needs high-leverage policies, practices and analyses that strengthen its technological capacity and competence more than ever before. Ankara Chamber of Industry's Provincial Technological Development Index (ASO-İLTEK 2025) analyses Türkiye's technology map at the level of all 81 provinces during this critical period, revealing both existing capacity and future risks through a data-driven approach.

ASO-ILTEK 2025 Results: Deepening Divergence and a Three-Layered Technological Geography

ASO-İLTEK 2025 results document that the asymmetrical distribution of technological development across Türkiye's geography is deepening and the gap between provinces is visibly widening, particularly in terms of digital infrastructure and qualified human resources. The index findings reveal that Türkiye's technology ecosystem is consolidated across three key layers. A key finding from the results is that Ankara and Istanbul have clearly separated themselves from all other provinces in the top ranks of ASO-İLTEK, forming their own leagues. Ankara maintains its position as Türkiye's technology production hub with its undisputed leadership in research and innovation capacity while Istanbul assumes the role of a global connectivity center with its digital infrastructure and commercialization power. These two centers alone account for more than 80% of Türkiye's high-tech exports, forming the backbone of national capacity.

Mid-Technology Fatigue in Industrial Giants and the Rising Anatolia

The report's most striking finding and an early warning for policymakers is the decline in performance experienced by the leading industrial giants. Eskişehir and Kocaeli which

were in the top (AA) category in 2024, have fallen to a lower category (BA) despite their strong production infrastructures, widening the gap with the leading duo in digitalization and research capacity. This situation demonstrates that traditional industrial production alone is no longer sufficient to maintain technological leadership; industrial centers that do not invest in digital transformation and a skilled workforce risk losing their competitiveness. In contrast, Kayseri has surpassed Istanbul and Ankara in the Technology Output sub-index, taking first place with its superior performance in patent, utility model and design registrations. This development has become Anatolia's most striking success story in combining production power with innovation. On the other hand, the increase in the number of provinces in the lowest technology category (FF) from 16 to 18 indicates the persistence of structural challenges in spreading technological transformation to the

Table 1 ASO İLTEK 2025 Results (Top 10)

Province	Rating	ASO İLTEK (Score)	ASO İLTEK (Ranking)	Ranking				
				Sectoral Structure	Research and Innovation Capacity	Digital Infrastructure	Technology Outputs	Quality of Life and Workforce Attractiveness
Ankara	AA	1,000	1	1	1	2	3	11
İstanbul	AA	0,962	2	2	3	1	4	23
Eskişehir	BA	0,675	3	4	4	10	5	16
Kocaeli	BA	0,666	4	3	2	8	8	13
İzmir	BB	0,539	5	5	5	5	9	24
Kayseri	BB	0,526	6	17	6	14	1	56
Bursa	BB	0,525	7	13	8	12	2	48
Sakarya	CB	0,401	8	18	10	36	6	32
Tekirdağ	CC	0,370	9	6	11	32	24	27
Antalya	CC	0,348	10	16	30	7	28	2

grassroots level and that regional inequality remains a risk factor.

The Leverage Effect of Defense Technologies and Their Diffusion into the Civilian Economy

The defense technologies which are the focus of the ASO-İLTEK 2025 report, demonstrate how Türkiye's strategic independence goals are becoming a powerful leverage in economic transformation. While the average export value per kilogram in Türkiye is \$1.57, the fact that this value exceeds \$65 in the defense and aerospace industry highlights the magnitude of the added value created by the sector. On the other hand, the defense industry is no longer just a security provider; it is an Ankara based deep technology incubator, where artificial intelligence, autonomous systems and advanced materials technologies are developed. Transferring the level of excellence achieved in this field to civilian industries such as automotive, healthcare and energy will be one of the most critical mechanisms for Türkiye to overcome the middle-income trap. The successes seen in the domestic production of ventilators or the integration of battery technologies into civilian vehicles during the pandemic are concrete evidence of this ripple effect.

The Determinant Role of Digital Infrastructure and the Problem of Qualified Human Resources

The Digital Infrastructure component which has gained increasing weight in the ASO-İLTEK 2025 index, has become a key determinant of development disparities between provinces. In provinces outside Istanbul, particularly those in the second tier with high industrial density, the insufficient fiber optic penetration and broadband access quality limit the economy's growth capacity. Similarly, the brain drain in the fields of artificial intelligence and advanced technology stands out as one of the biggest risks threatening Türkiye's innovation capacity. The report's findings indicate that provinces such as Muğla and Antalya while offering high quality of life and attractive workforce, lag behind in technology production; conversely, technology production centers also need improvement in quality-of-life parameters.

Future Vision and Strategic Roadmap

ASO-İLTEK 2025 offers proposals for rethinking Türkiye's technology policy, spatial decomposition of industrial policies, strengthening of a data-driven decision-making culture. The study's findings indicate that Türkiye needs a new, regionally focused and deep-technology-based industrial strategy to achieve a technological leap. The four main pillars of this strategy are:

Regional Response and Digital Mobilization: Region-based smart intervention tools should be implemented instead of general incentives to halt the decline of

should be launched in industrial zones outside of Istanbul to increase fiber optic coverage and accelerate the transition to 5G. For provinces that have not yet fully transformed their production capacity into branding like Kayseri and Bursa, Regional Development Programs focused on Digital and Green Transformation in Industry should be implemented to increase the per-kilogram value of exports.

Technology Transfer from the Defense Industry to the Civilian Economy:

The transfer of the level of excellence achieved in the defense industry to the civilian industry should be formalized within an institutional structure. "Dual-Use Technology Centers" should be established to facilitate the integration of technologies developed for military purposes like artificial intelligence, autonomous systems and advanced materials into the civilian sectors such as automotive, healthcare and energy. Ankara's defense-focused expertise should be directly channeled into high value-added production in the civilian sector, as exemplified by Biyovent and ASPILSAN.

Talent Management and Remigrating Brain Drain: To retain qualified human resources and attract global talent, the "Talent Magnet Cities" approach should be adopted. Technology Free Zones should be established in technology production centers (Ankara, İstanbul, İzmir) offering special accommodation, tax breaks and social benefits to researchers and entrepreneurs. Furthermore, in order to remigrate brain drain and raise future innovation leaders, elite talent programs inspired by global examples (such as the US's Kessel Run and Hacking for Defense; China's Civil-Military Fusion strategy; and Israel's Talpiot program) should be launched.

Digital Sovereignty and the Deep-Tech Initiative: Türkiye should extend its success from the software and gaming sectors to strategically in-depth technology fields. The development and public use of national large language models should be encouraged to promote data security and technological sovereignty. In parallel, a "National AI Directorate" should be established for AI governance and public-private venture capital funds should be created for high-risk areas such as biotechnology and quantum computing.

ASO-İLTEK 2025 shows that Türkiye is at a critical juncture in technological transformation. On one hand, there is the existence of a defense industry producing at global standards with a vibrant entrepreneurial ecosystem; on the other hand, there are traditional industrial zones struggling with digitalization and productivity. With concrete strategic moves, Türkiye will move into its rightful place in the global technology league through the integration of the capacity accumulated in Ankara and İstanbul with the production power of Anatolia.



INTRODUCTION

Globally, technology has transcended being merely a tool for innovation and productivity, becoming a key determinant of geopolitical power balances. The global technology competition, spearheaded by the US, China and the European Union, directly impacts the economic independence and strategic advantage of nations across a wide range of sectors, from semiconductors and artificial intelligence to defense technologies and the green transformation. In this competitive environment, the key factors are not just national actors but also urban ecosystems, industrial clusters and data-driven decision-making mechanisms.

In this process of reshaping global balances, Türkiye is emerging as a prominent player with its high potential. With its entrepreneurial dynamism, production capacity and the multiplier effect of its defense industry, Türkiye stands on the verge of moving beyond the middle-income group. However, this threshold can be overcome not only through national strategies but also through data-driven, location-specific interventions that strengthen the technological capacity of provinces. ASO-İLTEK was developed based on this need and goes beyond simply measuring provinces numerically; this project aims to evaluate Türkiye's technology production capacity through its provinces, make its potential visible and provide a data-driven framework for policymaking by revealing the structural obstacles in the technological transformation process.

“ The aim of ASO-İLTEK is to reveal regional technological disparities by presenting the technological development of provinces in Türkiye in a multi-dimensional and comparable manner and to contribute to evidence-based policy design. In this respect, ASO-İLTEK is not just an index but a strategic analysis tool that supports Türkiye's transition to a high value-added and competitive production structure. ”

The report's message is clear: Türkiye's fundamental problem is not a lack of technology production capacity but its inability to transfer its existing expertise to higher technological levels. In this context, under changing geopolitical and economic conditions, industrial policies should evolve from a uniform and general incentive approach to a data-driven, province-specific, targeted and results-oriented structure. To answer this need for transformation, ASO-İLTEK 2025 offers policymakers a strategic guideline, the business world a frame of reference to evaluate its current position and universities and research institutions an analytical platform outlining their areas of responsibility.

ASO-İLTEK has adopted a thematic framework this year, designating defense industry technologies as the technology theme of the report. The defense industry is of strategic importance in demonstrating the level of technological production capacity Türkiye has reached and the potential for this expertise to spread throughout the economy. According to export data from the Turkish Exporters' Council, the export value per kilogram in the defense and aerospace industry exceeded 65 USD in 2024, reaching approximately 44 times the average export value of 1.57 USD for Türkiye. This striking difference reveals the sector's knowledge-intensive and technology-driven nature and proves its leading role in Türkiye's strategy to escape the "middle-income trap." The defense industry is at the heart of high value-added production in many critical areas such as advanced materials, artificial intelligence, software, electronics and aerospace technologies, creating a powerful technology multiplier. Within this framework, the Report comprehensively evaluates the diffusion of competencies developed in the defense industry to civilian sectors through technology transfer, its regional impacts and its contributions to Türkiye's global competitiveness. It is emphasized that the defense industry serves as a critical leverage not only in the field of security but also in terms of sustainable development and industrial transformation.

Another important role of the ASO-İLTEK study is that it is an organic and complementary part of the Ankara Chamber of Industry's (ASO) long-term strategic vision focused on Technology, Sustainability and Innovation. ASO aims to increase Ankara's global competitiveness through green and digital transformation projects, programs aimed at strengthening the technology and entrepreneurship ecosystem, the ASO Technology Base Project and analytical studies guiding the transformation of industry. ASO-İLTEK aims to translate this strategic vision into a data-driven framework, providing a guiding reference frame for policymakers, investors and industry stakeholders. In this respect, ASO-İLTEK offers a holistic strategic approach that contributes to Ankara's and Türkiye's technology-oriented development goals.

ASO-İLTEK is based on a multidimensional index approach that evaluates the technological development levels of provinces in a comparable manner. This study adopts a data-driven, objective and multidimensional statistical approach when measuring the technological

development levels of provinces. In order to minimize subjective biases and to base the calculation of the index on the natural distribution of the data itself, the Principal Components Analysis (PCA) method was used.

ASO-İLTEK 2025 consists of five sub-indices and 37 variables, compiled from reliable national data sources, covering Sectoral Structure, Research and Innovation Capacity, Digital Infrastructure, Technological Outputs, Quality of Life and Workforce Attractiveness. The indicators were normalized and weighted according to the defined methodology and converted into a single index score to allow for comparisons between provinces. Thus, the study aims both to track changes over time and to provide a data-driven foundation for policy design.

The ASO İLTEK 2025 Report consists of five sections. **The first section** examines the prominent digital, green and social transformation trends in the global economy by 2025; the impact of geopolitical tensions on technology and trade, as well as emerging critical technologies are discussed, along with Türkiye's position within this transformation.

The second section examines Türkiye's performance in international indices, particularly the Global Innovation Index and artificial intelligence and technology ecosystem indicators while evaluating key regional technology indicators.

In the third section, the ASO-İLTEK 2025 results are analyzed in detail; the overall index and sub-index performance of the provinces, technology belts and regional differentiations are presented from a holistic perspective.

The fourth section focuses on defense industry technologies as the Technology Theme, examining global trends, Türkiye's capabilities, the structure of the defense ecosystem and the potential for the spill-over of technological expertise in this field to civilian sectors.

The fifth and final section presents policy recommendations and strategic priorities to support technology-based development in Türkiye and its provinces, based on the findings of the report.

The previous ASO-İLTEK Report published in 2024, provided an objective comprehensive assessment of Türkiye's technology landscape while the 2025 update offered the opportunity for a comparative analysis. ASO-İLTEK has enabled the comparative monitoring of developments in the technology production capacity of the provinces and a more accurate measurement of the impact of policies with its indicator and data analyses for 2023, 2024 and 2025. As the data set expands over the coming years, Türkiye's technological transformation journey will be analyzed in depth and the Report will become a lasting reference source for both policymakers and the business world.

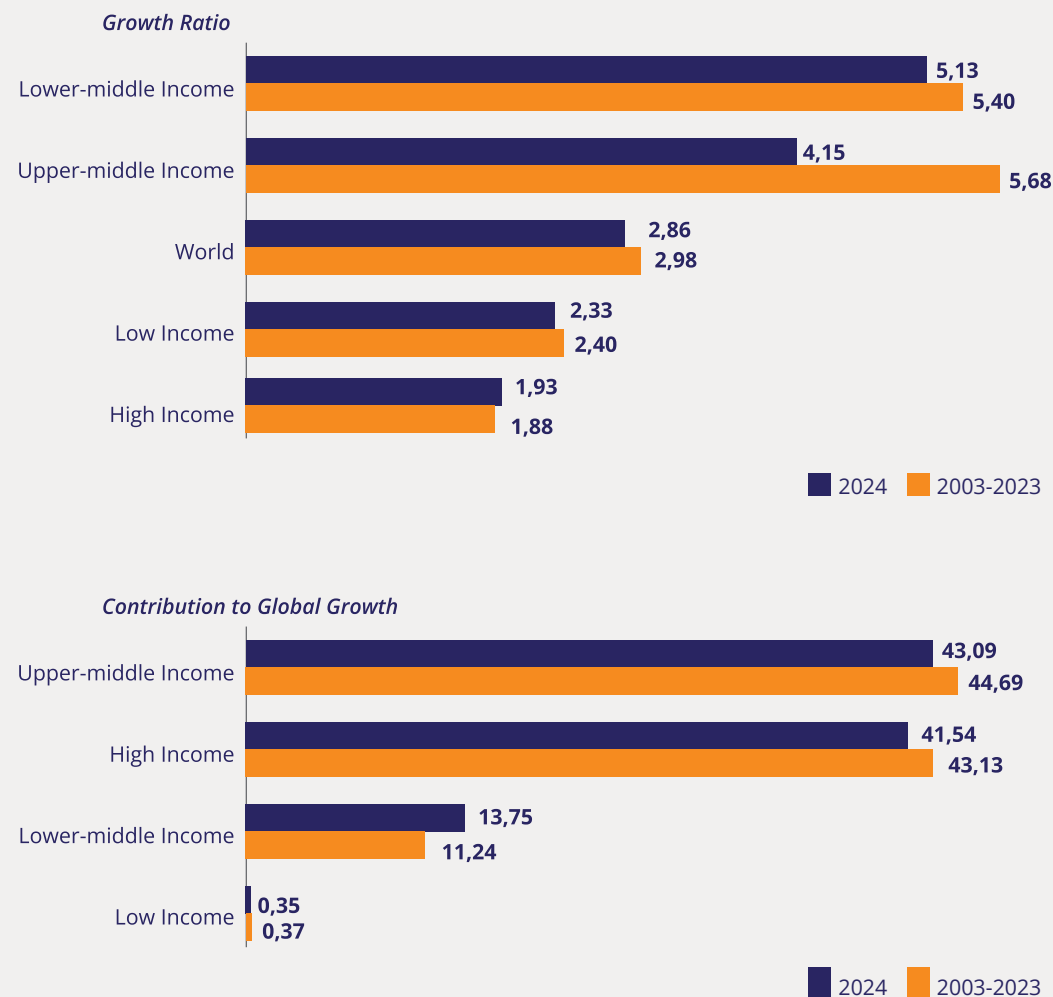


1. TRANSFORMATION IN THE GLOBAL ECONOMY: 2025 TRENDS

As the global economy enters 2026, growth rates, productivity dynamics and competitive conditions are being reshaped by a series of interconnected waves of transformation. Digitalization, the energy transition, societal changes, geopolitical tensions and new industrial and trade policy approaches have become the main axes determining the long-term trajectory of the world economy. These axes present opportunities that support productivity and create new markets, but they also reveal new risks in terms of supply chain sustainability, inequality, employment and financial stability.

World Bank data shows that global growth in 2024 fell below historical averages. As shown in Figure 1.1, excluding high-income economies, the average growth rate for all income groups in 2024 was below the average growth rate of the 2003-2023 period. Conversely, the contribution to global growth was significantly above the historical average, particularly in the lower-middle income group of countries. As global growth remains below historical averages, a similar weakness is observed in productivity indicators. World Bank data shows that global GDP per worker increased by only 1.42% in 2024, significantly lagging behind both the 2003-2023 average of 2.13% and the 2013-2023 average of 1.85%.

Figure 1.1. Average Growth Rate of Economies by Income Group and Their Contribution to Global Growth (%)



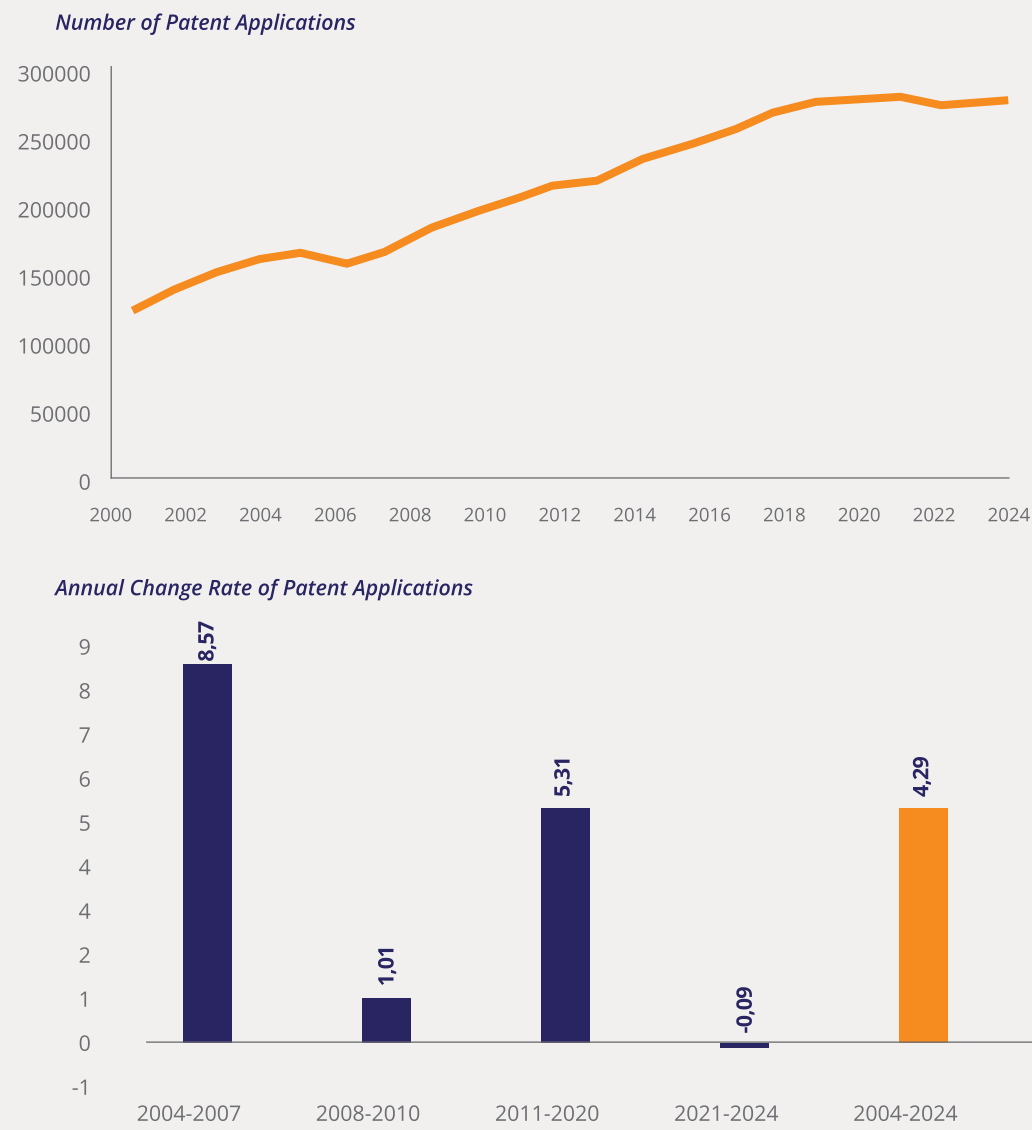
Source: World Bank

This outlook suggests that productivity dynamics are failing to provide the necessary momentum for global growth. On the other hand, WIPO's findings show that hourly output, as an indicator of labor productivity, increased by 2.5% in the 2023-2024 period, thus remaining close to the compound growth rate of 2.2% of the last decade (WIPO, 2025a). These data reveal that productivity growth in the global economy has not completely stopped but productivity gains are distributed quite unevenly across countries and sectors. Therefore, while global growth is weak, a picture emerges where productivity growth is accelerating in certain country groups, but these gains are not spreading across the world.

“As the global economy remains trapped in a low-growth cycle, the disparity in productivity increases across countries and sectors is becoming increasingly apparent.”

It is noteworthy that in a period of uneven distribution of productivity, channels for innovation and knowledge production have not completely weakened. WIPO estimated that global R&D spending would increase by 2.9% year-on-year in 2024, reaching 3.2% for companies with the highest R&D expenditures. The most significant increase in the field of innovation has been in the number of scientific articles. In 2024 when the threshold of 2 million scientific publications was surpassed, the increase in the number of publications compared to the previous year was 7.6%. On the other hand, the outlook on the venture capital side has been quite different. Excluding AI and US-based mega-deals, global venture capital investments continued to decline in 2024. While deal values collectively increased by 7.7% in 2024, this increase was largely driven by very large-scale transactions in the US and significant capital flows towards generative AI. Excluding these items, it is evident that global venture capital has contracted and investment appetite remains quite limited. The most striking finding is the decline in the number of transactions: Global venture capital transactions fell by 4.4% in 2024, marking the third consecutive year of decline (WIPO, 2025a). This trend indicates that investors remain cautious towards sectors outside of artificial intelligence and information and communication technologies, as well as regions outside the US; and that the sector and regional diversification observed in previous years has largely decreased.

Figure 1.2. Development of the Number of International Patent Applications Worldwide



Source: WIPO.

In international patent applications, a limited recovery occurred in 2024 following the exceptional decline in 2023. WIPO data shows that international patent applications increased by 0.5% year-on-year in 2024; However, this increase remains low growth rate of 4.29% for 2004-2024 (Figure 1.2). When examining the period 2004-2024, four periods stand out in terms of international patent applications: 2004-2007 when applications grew at a compound annual rate of 8.57%; 2008-2010 when the compound annual growth rate slowed to 1.01%; 2011-2020 when acceleration began again and the compound annual growth rate was 5.31%; lastly, 2021-2024 when stagnation was evident and the compound annual growth rate was -0.09% (Figure 1.2). On the other hand, there are significant differences between countries in the growth of patent applications. This indicates that despite the strong scientific publication performance of the global innovation ecosystem and the increase in companies with high R&D spending, the intellectual property production side is still in a weak and uneven recovery process.

“Intellectual property efforts are still in a weak and uneven recovery phase despite strong global innovation, R&D and scientific output.”

All these indicators suggest that the global economic environment is undergoing a "rebalancing" process characterized by weak growth but continued investment in innovation. Within this framework, the megatrends of 2025 are discussed under five headings. Firstly, digital, green and social transformations are discussed. The second focuses on the effects of geopolitical tensions on technology and trade. Third heading addresses rising competition and technological convergence in critical technologies. Fourth, discusses new industrial policy approaches spearheaded by the United States, Europe and China. Last heading evaluates potential scenarios regarding the relationship between production, technology and the economy in the context of achieving the 2030 targets.

1.1. Digital, Green and Social Transformation

Digital transformation continues to be a key driver of increased productivity and new business models in the global economy. According to World Bank data, fixed broadband subscriptions increased by an average of 8.2% annually worldwide between 2014 and 2024. By 2024, there will be 19.6 fixed broadband subscriptions per 100 people. Penetration is much higher in mobile broadband; there are 153 subscriptions per 100 people in high-income countries, 112 in upper-middle-income countries, 66 in lower-middle-income countries and 40 in low-income countries (WIPO, 2025a). The widespread adoption of fifth-generation mobile communication technology is changing the nature of this infrastructure. Between 2020 and 2024, 5G coverage increased by an average of 53.6% annually; by 2024, approximately 51% of the world's population would be covered by 5G. However, 5G coverage is 84% in high-income countries while it remains at only 4% in low-income countries (WIPO, 2025a). This imbalance means that productivity gains in the digital economy occur at different rates across countries.

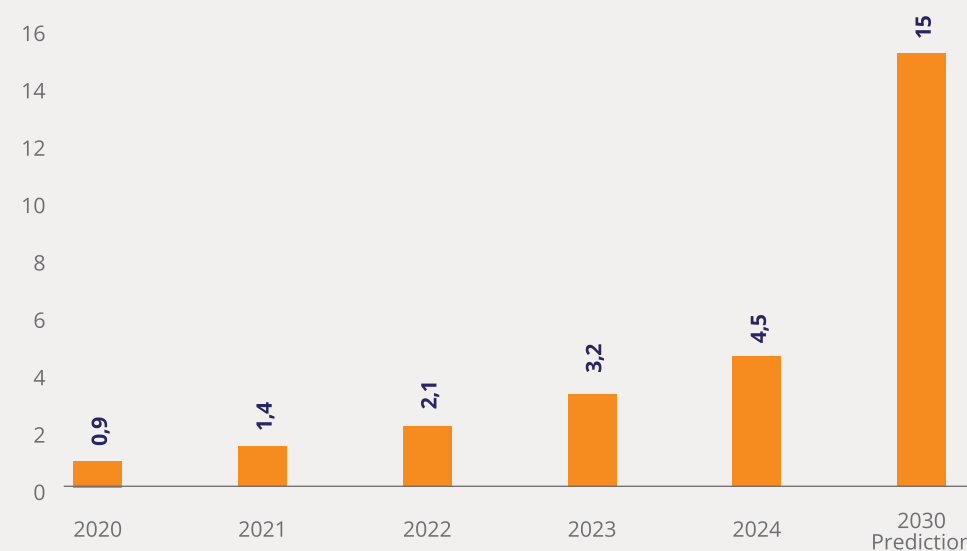
Digital transformation is not simply the expansion of internet infrastructure but a radical change in production technologies and business practices. The primary driving force behind this change is the increase in computing capacity.

“Differences in digital infrastructure have become a critical threshold that sharply transforms the productivity gains of the digital economy into either a strategic advantage or a direct disadvantage.”

WIPO (2025a) data indicates a two-pronged advancement in hardware: speed and efficiency. Between 2014 and 2024, the number of transistors in the most advanced microprocessors increased at an average annual rate of 42%, resulting in a significant increase in processing power. During the same period, an examination of the world's 50 most efficient supercomputers revealed that their processing capacity per unit of energy consumed (energy efficiency) increased by 65.7% (WIPO, 2025a). Data presents that the infrastructure powering AI applications has not only become stronger but has also evolved to optimize energy costs. This robust and efficient hardware infrastructure facilitates the integration of AI into industry, finance and public services, both technically and economically.

The green transformation is gaining momentum, particularly with cost reductions and technological developments in energy systems. Between 2010 and 2023, the cost of electricity production from solar photovoltaic systems decreased by approximately 90%; while the cost reduction for onshore wind power plants approached 70%. As a result of these developments, in terms of unit electricity cost, solar energy has become a technology that produces electricity at a cost 56% lower than the cheapest fossil fuel option by 2023 while onshore wind energy is 67% cheaper. During the same period, lithium-ion battery prices decreased by approximately 85% compared to their 2013 levels, falling to a real level of US \$115 per kilowatt-hour in 2024 (WIPO, 2025a). Thus, data show that electric vehicles and energy storage solutions are gaining a competitive advantage in terms of cost.

Figure 1.3. Share of Electric Passenger Vehicles in the Total Number of Passenger Vehicles (%)



Source: International Energy Agency

The electric vehicle stock is one of the tangible indicators of the transformation in the energy and transportation sectors. According to IEA data, between 2014 and 2024, the global electric vehicle stock recorded a compound annual growth of 53.6% and by 2024, 4.5 out of every 100 passenger cars in the world will be electric (IEA, 2025). Between 2023 and 2024, the global electric vehicle stock increased by 18 million units, representing a growth rate of 45%. Although this growth rate indicates a slowdown compared to previous years, the market share of electric vehicles is increasing significantly, particularly in China, some European countries and a growing number of emerging economies. The combination of falling battery costs for electric vehicles and the decline in unit costs of renewable energy production strengthens the economic rationale for the green transition. As a result of these developments, the IEA estimates that the share of electric passenger vehicles in the total passenger vehicle stock will rise to 15% in 2030 (Figure 1.3).

Signs of progress and vulnerability are visible when looking at the social transformation dimension. For example, OECD-LinkedIn data shows that global AI skills which were 0.4% for men and 0.2% for women in 2016 are steadily increasing to 0.8% for men and 0.5% for women in 2024. However, the same data points to a significant difference in artificial intelligence capabilities between developed and developing economies. As shown in Figure 1.4, the AI proficiency rate for 2024 is 1.98% in Israel, 1.65% in Singapore, 0.23% in Brazil and 0.28% in Mexico. The average AI proficiency rate for high-income economies shown in Figure 1.4 is 0.84% while the same rate is 0.3% in upper-middle-income countries (OECD, 2025a).



“ The global gap in AI skills stands out as a major risk limiting the pace of digital transformation in developing economies. ”

Figure 1.4. Artificial Intelligence Capabilities (% , 2024)

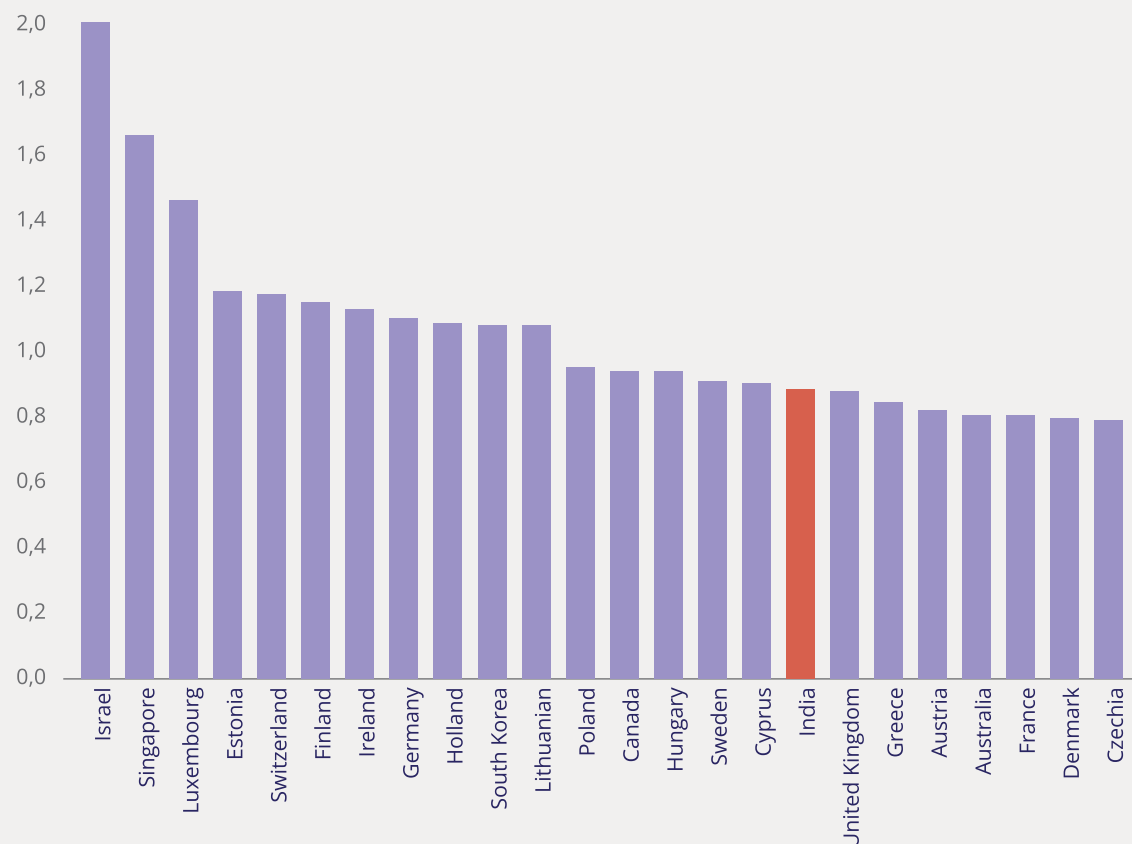
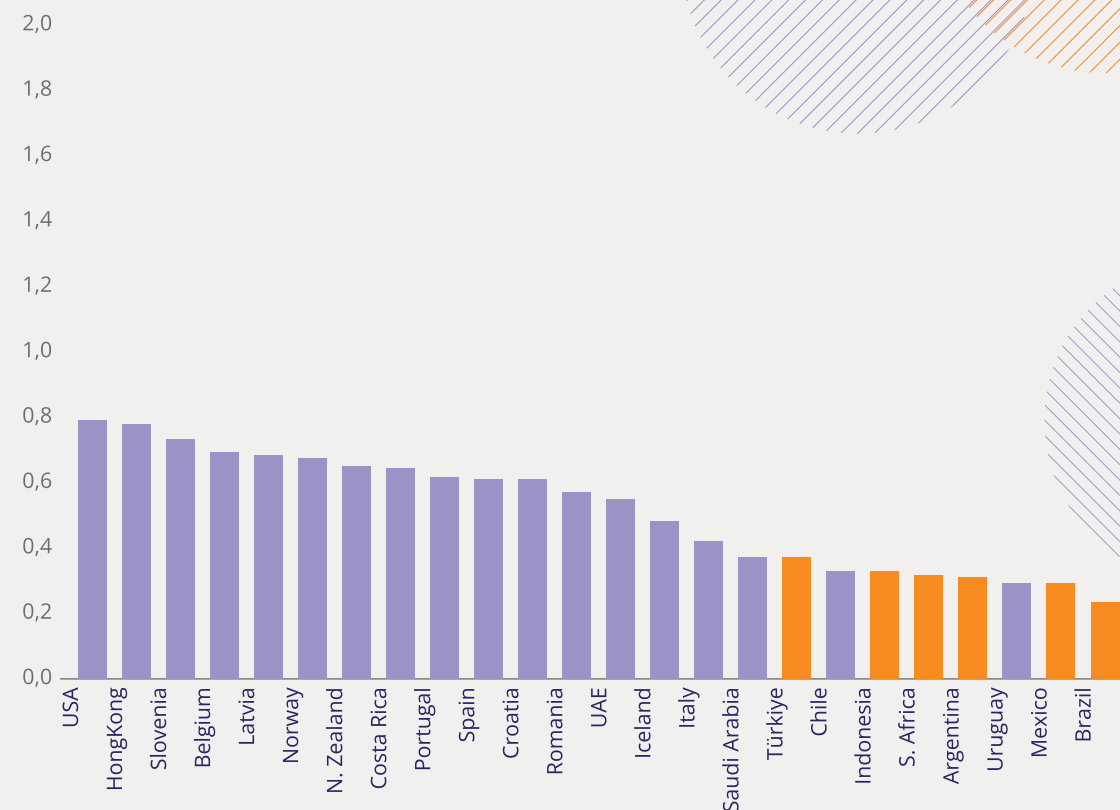


Figure 1.4. Artificial Intelligence Capabilities (% , 2024)



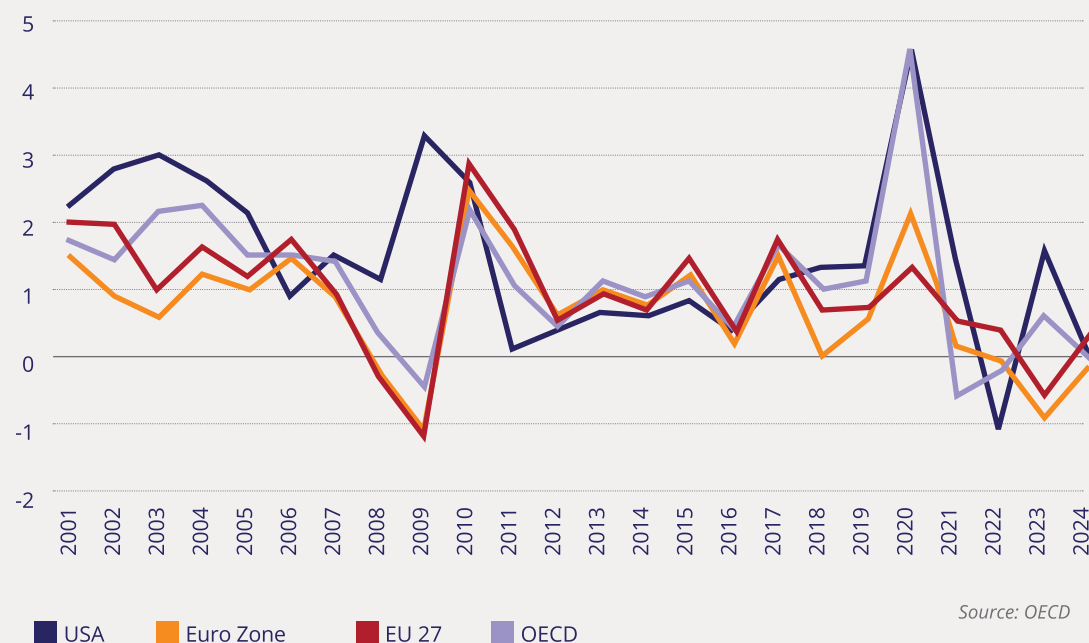
Source: OECD AI Policy Observatory.

Note: Countries marked in orange are upper-middle income countries while India, marked in red, is the only lower-middle income economy on the list. All other economies marked in purple are in the high-income category.

The most notable development in AI skills is the migration of talent from economies with already low skill density to more developed economies. According to OECD-LinkedIn data for which AI net migration rate data is available, out of the 48 countries for 2024, 16 are net emigration economies and all of the upper-middle or lower-middle income economies listed in Figure 1.4 fall into this category (OECD, 2025a). This situation stands out as a slowing factor in the adaptation of developing economies to digital transformation and risks triggering convergence problems in terms of productivity and growth for these economies in the medium to long term.

OECD data shows that this transformation has not yet created a lasting leap in productivity but there have been significant improvements in productivity dynamics. In 2023, the average hourly GDP growth in OECD countries remained at only 0.6%; this rate was significantly below the performance of the early 2010s. Labor productivity in the Euro Zone fell by 0.9% in 2023, its sharpest decline since 2009 while the United States recorded a 1.6% increase in the same year (Figure 1.5). Projections for 2024 indicate an increase in labor productivity of approximately 0.4% across the OECD, suggesting a weak recovery (OECD, 2025b).

Figure 1.5. Annual Change in GDP per Hour Worked
(PPP Adjusted, 2020 Constant Prices, %)



This weak performance in productivity growth becomes clearer when looking at the components of growth. In 2023, the largest contribution to GDP growth in OECD countries came from increases in employment and total hours worked; the contribution of capital accumulation remained limited and the multi-factor productivity contribution was negative in most countries (OECD, 2025b). This table suggests that weakness in investment trends and slow diffusion of new technologies among firms are creating persistent pressure on labor productivity (OECD, 2025b).

The fact that labor productivity performance in 2023 is negative in approximately half of the OECD countries means that labor productivity is dragging growth down in a significant number of OECD countries. Within some European economies, high energy prices, weak demand and measures to protect employment have led to a slowdown in production and a decline in per capita output. In contrast, productivity increases in some Central and Eastern European and Latin American economies stand out as exceptions that are pulling up the overall OECD average.



“ Although digital and intangible investments are increasing, the impact of this transformation on productivity has not yet reached the maturity needed to create a strong momentum on a macro scale. ”

Looking at the composition of labor productivity growth, it appears that the weak performance in 2023 stemmed largely from a slowdown in multi-factor productivity. In many countries, the contribution of capital deepening has turned close to zero, or even negative; and the contribution of multifactor productivity has remained significantly below the long-term average. This situation also reflects a change in the composition of investment. Indeed, although there is an increasing shift towards digital and intangible assets compared to traditional physical capital, these investment categories are not yet on a scale or widespread enough to create a strong productivity boost at the macro level. Therefore, digital and green transformation is more of an "infrastructure investment" that shapes the future productivity increase potential of companies and sectors. On the other hand, it is predicted that productivity increases in macroeconomic indicators will only occur in a gradual and heterogeneous manner.

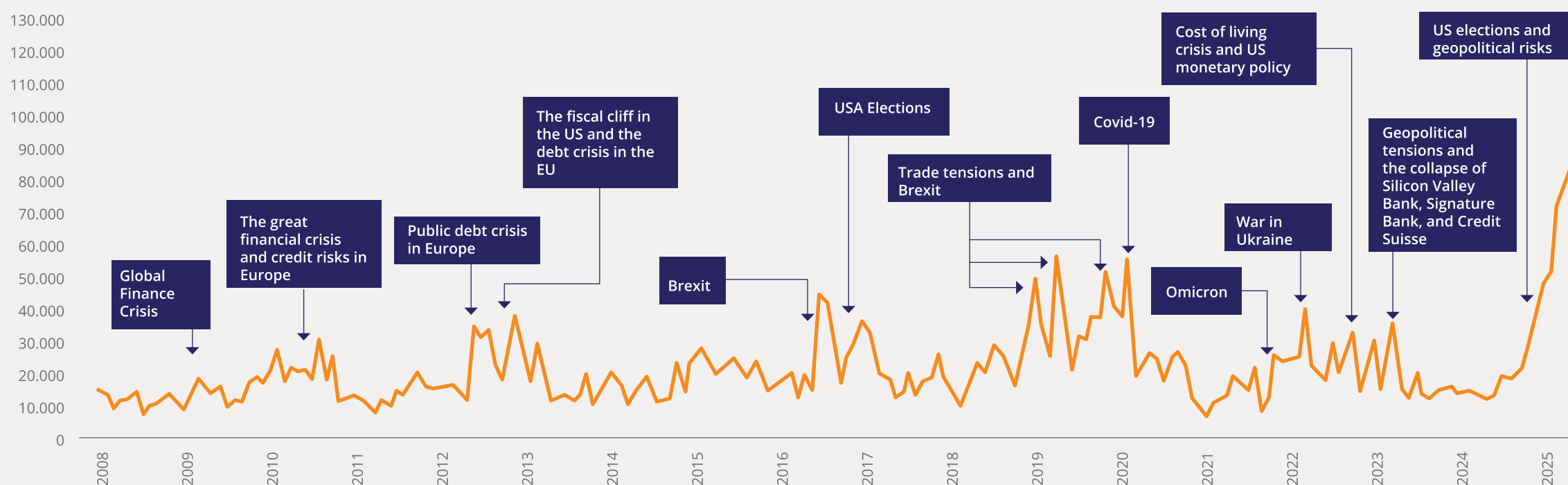
These trends in productivity and talent mobility are also triggering profound changes in the social fabric. The transformation driven by automation and artificial intelligence is making the need for workforce to reskill an urgent economic and social policy agenda item. If inclusive policies are not developed during this process, the gap between those who produce and utilize technology most effectively and the traditional workforce is likely to widen, and social vulnerabilities are likely to increase.

1.2. Geopolitical Tensions and the Technology-Trade Race

The global economy entered 2025 in a period marked by significantly increased geopolitical tensions, weakened channels of international cooperation and increasingly fierce geo-economic competition. The World Economic Forum's Global Risks Report 2025 findings indicate that interstate conflict, geo-economic decoupling and information manipulation are among the top priorities in the perception of global risks. In the report, 23% of participants identified state-sponsored armed conflict and more than 10% identified geo-economic conflict as among the most likely risks of 2025 (WEF, 2025a). Similarly, the Mistræ Geopolitics study and the Geneva Geopolitical Tensions Report highlight that both political and economic uncertainties at the global level have become structural throughout the 2020s (Talebian and Lager, 2025; Chari et al., 2025). This environment creates multifaceted pressure that reduces stability in global trade, technology investments and supply chains.

One key indicator of this pressure is the increase in world uncertainty levels. The World Uncertainty Index, derived from macroeconomic and geopolitical news texts worldwide, has moved away from its low levels in the early 2000s and settled on a path above historical averages following shocks such as the 2008 crisis, the 2011 European debt crisis and the 2020 pandemic. As shown in Figure 1.6, an upward trend was observed in the index again in the post-2022 period due to the Russia-Ukraine crisis, conflicts in the Middle East and the intensification of US-China competition (Ahir, Bloom and Furceri, 2023). When uncertainty becomes persistent on this scale, it affects a wide range of areas, from countries' policy choices to firms' investment appetite.

Figure 1.6. World Uncertainty Index



Source: worlduncertaintyindex.com, Ahir, Bloom ve Furceri (2023).

Note: The Global Uncertainty Index (WUI) is calculated by analyzing the text of Economist Intelligence Unit (EIU) country reports covering 143 countries. The index value is obtained by dividing the frequency of use of the word "uncertainty" and its derivatives

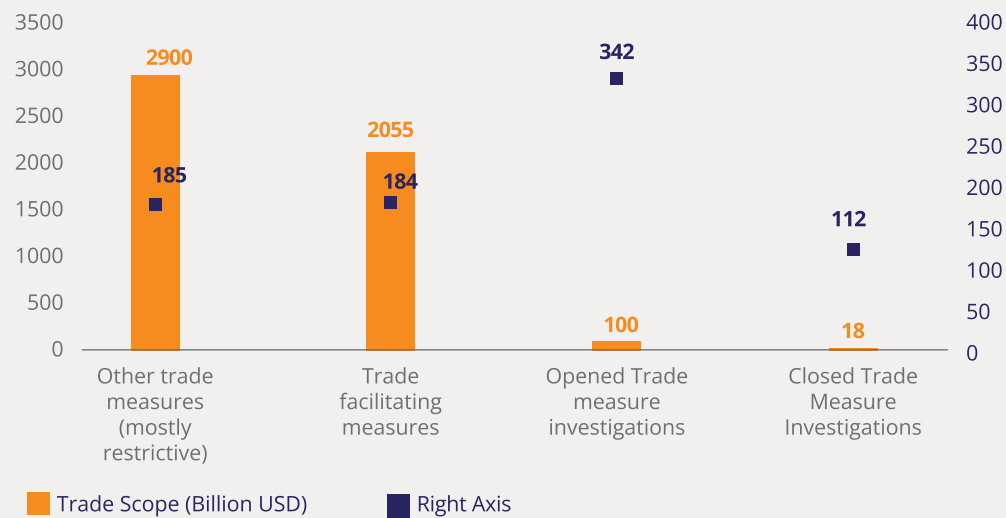
by the total number of words in these reports. The global index is based on the GDP weights of the countries and has been rescaled by multiplying by 1 million. An increase in the index indicates a decrease in economic and political predictability.

The economic repercussions of geopolitical tensions continue to increase uncertainty in global trade policies. The World Trade Organization's (WTO) 32nd G20 Trade Measures Report, dated November 2025, confirms this trend with data covering the period October 2024-October 2025 (WTO, 2025). The report documents that G20 economies implemented a total of 823 new trade measures during this period. As shown in Figure 1.7, 342 of these measures are trade defense instruments, 184 are trade facilitation measures and 185 are categorized as "other trade measures" which mostly have a restrictive effect.

Beyond this record number of measures, the most striking change has been in the volume of trade covered by these measures. During the reporting period, trade facilitation measures covered a volume of US \$2.055 trillion while other restrictive measures reached US \$2.9 trillion. This marks the first time since 2009 that restrictive measures have outpaced facilitative measures in terms of volume.

More importantly, there is the stock effect created by restrictions from the past that remain in effect. The cumulative scope of import restrictions accumulated since 2009 has risen to US\$4.015 trillion by the end of 2025. This amount represents 22% of total G20 imports and 16.9% of world goods imports (WTO, 2025). In other words, more than a fifth of G20 countries' imports are now under the shadow of restrictive measures. This picture concretely demonstrates that global trade is becoming increasingly fragmented, defensive and costly.

Figure 1.7. G20 Trade Measures and Their Trade Volume (October 2024-October 2025)



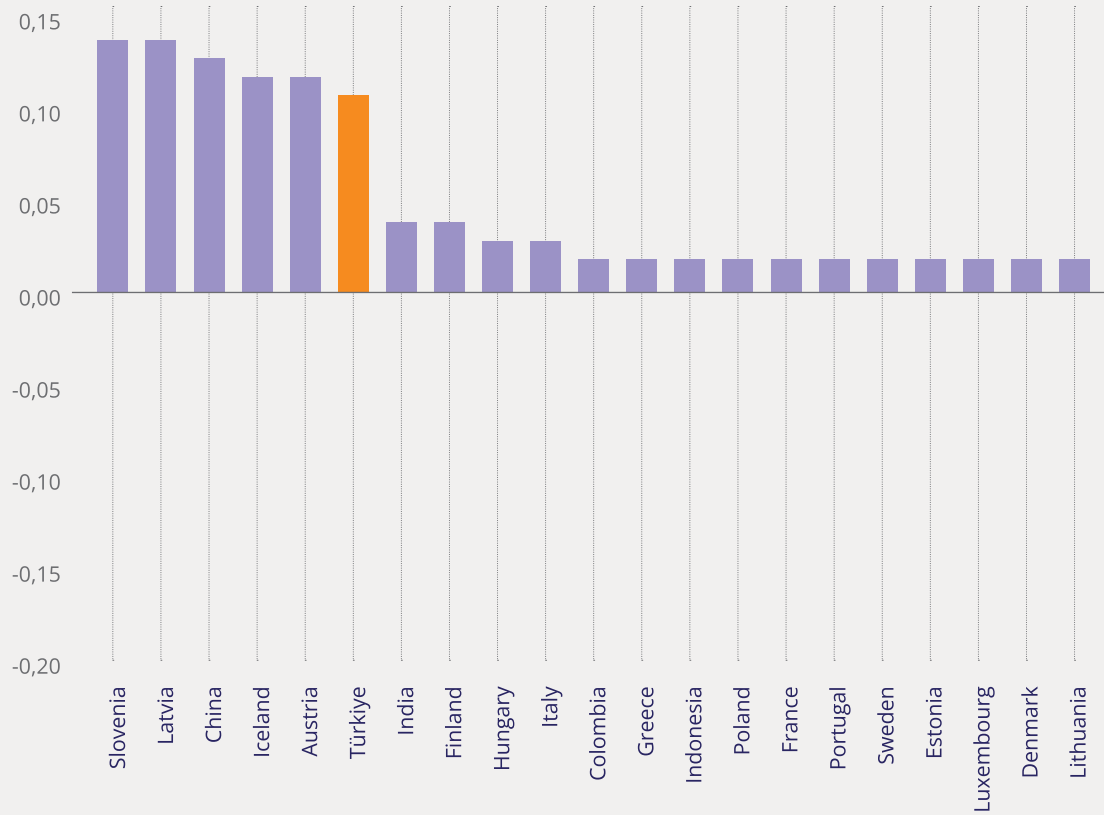
Source: World Trade Organization

The direction of trade flows also changed significantly during this period. US imports from China decreased by 12% between 2017 and 2024 and China's share of total US imports fell from 21.9% to 13.8% (8.1 percentage points) during the same period. The European Union experienced a rapid decline in energy and certain intermediate goods imports from Russia after 2022 (Attinasi et al., 2024). In contrast, countries such as Mexico, Vietnam, India and Indonesia are seeing strong increases in their exports to US and European markets. The European Central Bank's findings on global trade flows support this trend, showing that some product groups are now entering the US and EU from China via third countries. Similarly, UNCTAD's global trade updates reveal that Asian economies will have strong trade performance in the first half of 2025 while US imports will decline during the same period (UNCTAD, 2025). This picture shows that global supply chains have not broken down but have evolved into a long, complex and costly structure.

Geopolitical pressures are deepening the divide not only in physical goods trade but also in the digital economy and data-driven sectors. OECD indicators of restrictiveness in digital services trade have increased in recent years due to data localization requirements, national security-based regulations in cloud services and restrictions on digital service providers. The Digital Services Trade Restrictiveness Index (OECD, 2025c) increased in 26 of the 43 countries for which data is available from 2016 to 2024, remained stable in 13 and decreased in only 4 (Figure 1.8). The 28th Geneva Report similarly emphasizes that international digital payment systems, communication infrastructures and data centers are increasingly subject to geopolitical competition (Chari et al., 2025). The NATO Parliamentary Assembly's 2025 Report notes that critical infrastructures are being re-evaluated under the national security lens, particularly due to cybersecurity and strategic dependency concerns and that this is accelerating regional bloc formation in digital services trade (Kroon, 2025). These developments are transforming the digital economy from a global marketplace into an area defined by political borders.



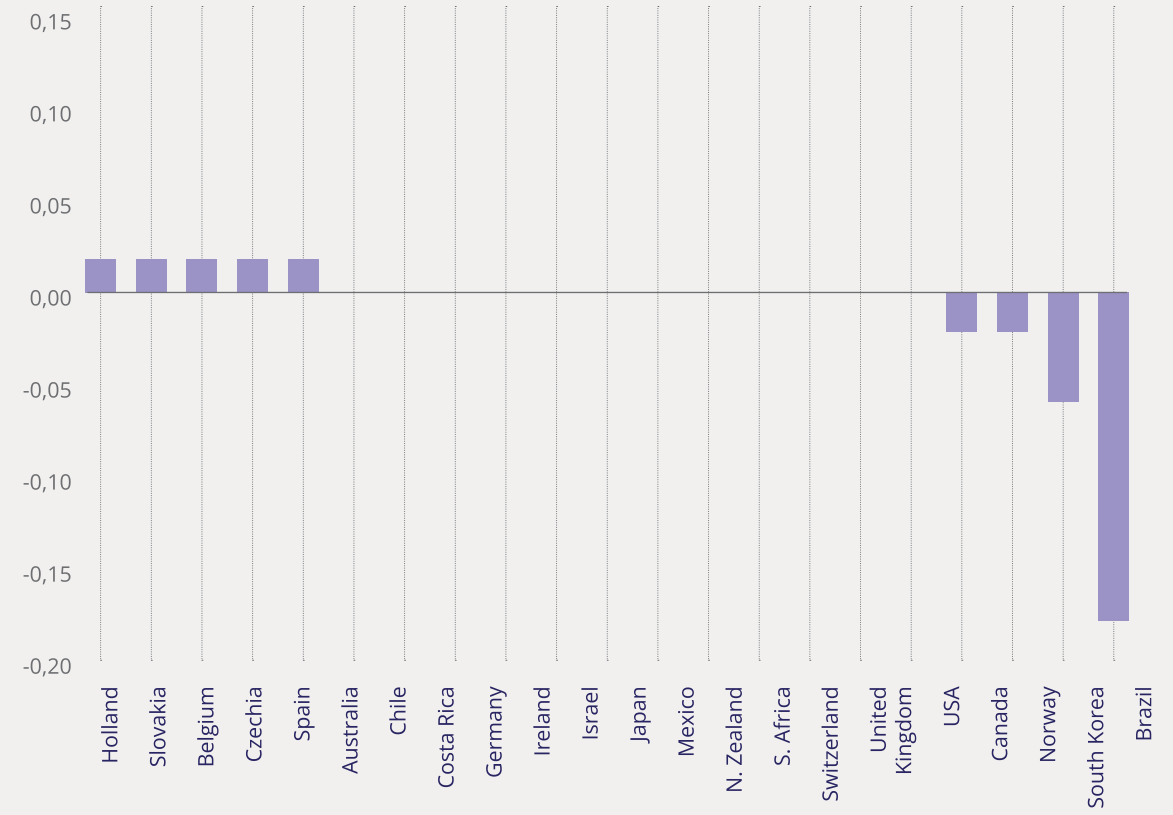
Figure 1.8. Changes in the Digital Services Trade Restrictiveness Index 2016-2024



Source: OECD. Note: An increase in the index signifies increased restriction.

The interaction between trade and technology has acquired a new character in this context. Trends in the global trade of advanced technologies are now shaped not only by market dynamics but also by geostrategic concerns. UNCTAD's 2025 assessment shows that growth in trade in electronic goods significantly exceeds the increase in trade volume in general manufactured goods; one of the main reasons for this is the demand for IT infrastructure required by artificial intelligence systems (UNCTAD, 2025). A European Central Bank study (Attinasi et al., 2024) reveals that US export controls on products such as semiconductor equipment and high-tech components, along with European measures to reduce strategic dependence are reshaping trade flows. China's export licensing practices for critical minerals and the US's expanded control regimes on semiconductor equipment are reinforcing this trend.

Figure 1.8. Changes in the Digital Services Trade Restrictiveness Index 2016-2024



Similarly, the NATO Parliamentary Assembly's report entitled "Geo-economic Fragmentation: A Challenge to Transatlantic Partnership" emphasizes that critical minerals, battery ecosystems and telecommunications components are becoming an area of strategic as well as economic competition (Kroon, 2025).

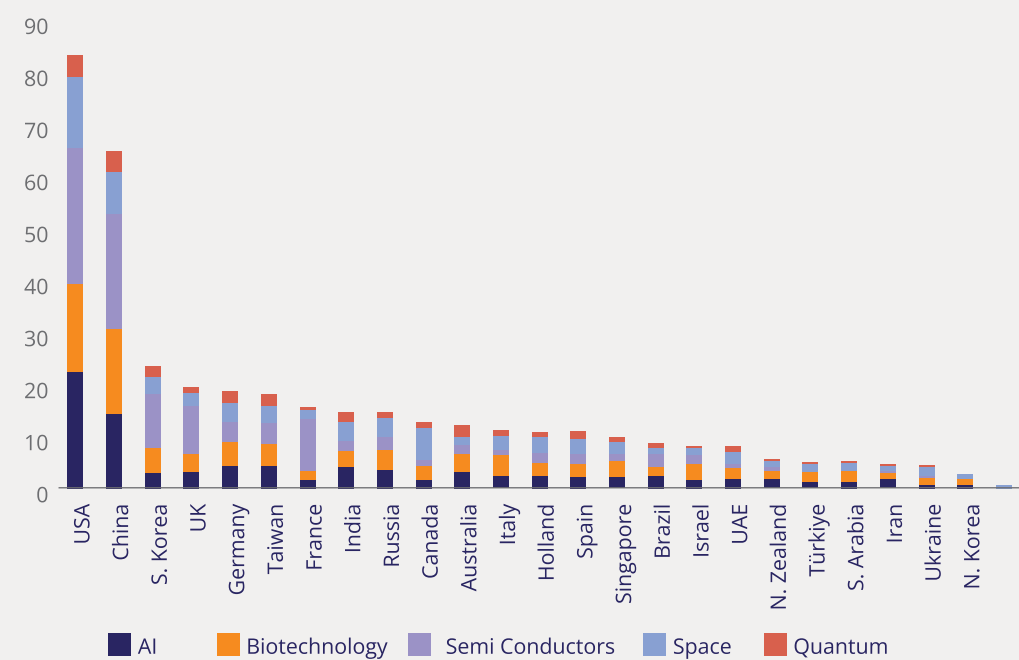
When combined within this framework, geopolitical tensions are redefining global trade in terms of volume, direction and technological composition. The trading system has moved away from a trend towards liberalization and has evolved into a more protectionist structure based on blocs and selective restrictions. Technology commerce is increasingly regulated by security-based policy tools and commercial decisions are becoming intertwined with strategic objectives. This transformation is projected to be decisive for growth, investment and supply chain stability in the post-2025 period. Section 1.3 will detail the technology clusters and critical technologies underlying this competition.

1.3. Emerging Critical Technologies and Technological Convergence

The direction of the technology race in the global economy has changed significantly by 2025 and the defining characteristic of this era has become not only the advancement of core technologies within their own fields but also their interaction with each other, creating new production capacities and economic models. The Critical and Emerging Technologies Index, prepared by the Belfer Center at the Harvard Kennedy School, comparatively assesses the position of countries in five critical areas: artificial intelligence, semiconductors, biotechnology, quantum technologies and space systems and this assessment clearly reveals the technology areas that form the focus of global competition (Harvard Kennedy School Belfer Center, 2025). According to the index results, the United States maintains its leading position, particularly in artificial intelligence, quantum and space-based systems while China has rapidly scaling capacity in semiconductor manufacturing, battery technologies, biotechnology and next-generation energy materials. The European Union while competitive in basic sciences with its strong research infrastructure is in a more limited position in areas requiring large-scale production (Figure 1.9). This balance of power demonstrates that national strategies in critical technologies are determined not solely by scientific output but also by the speed of commercialization, supply chain resilience and standardization strength.

“Critical technologies are no longer isolated fields; they have transformed into a strategic structure that shapes the direction of global competition by forming an ecosystem where each aspect reinforces the others.”

Figure 1.9. Harvard Kennedy School Belfer Center Critical and Emerging Technologies Index (2025, 0-100)



Source: Harvard Kennedy School Belfer Center. Note: The values in the graph represent the national power score (index score from 0-100) in the relevant technology field

This table also illustrates that each of the critical technologies is not progressing in isolation but rather transforming into a structure that creates value by being more integrated with each other. Artificial intelligence is at the heart of this integration. Info-Tech Research Group's Technology Trends 2026 report emphasizes that artificial intelligence has now moved into the "transformative technology" category. According to the report, as well as efficient on-device models and multi-agent systems, generative AI models are rapidly becoming widespread; organizations are beginning to integrate these systems into their workflows (Info-Tech Research Group, 2025). Multi-agent architectures offer teamwork where "virtual workers," each specializing in a different task, communicate with each other to solve complex tasks, rather than being limited by the processing boundaries of a single AI model. Standards such as the Model Context Protocol (MCP) enable AI tools to interact securely and consistently with real-time data sources, inbound institutional applications and third-party services (WEF, 2025b).

This structure signifies not only an increase in algorithmic capacity but also the penetration of artificial intelligence into other critical technology fields. Particularly in the field of engineering biology, the development of AI-integrated precision biomanufacturing models enables data-driven design of biological processes and scalable production systems. The World Economic Forum's (WEF) Technology Convergence Report (WEF, 2025b) shows that the combination of engineering biology and artificial intelligence creates three fundamental transformations. First, AI modeling of multi-layered biological data enables the rapid optimization of many complex processes, from enzyme design to cellular metabolism. Secondly, biosensors and neurobiological interfaces that connect biological data streams to digital systems make it possible for biological signals to work with electronic decision-making mechanisms, leading to new applications in fields such as health, energy and food. Thirdly, bioprinters and robotically automated cell culture platforms are paving the way for industrial-scale biological production.

“ In the near future, economies of scale resulting from the integration of artificial intelligence, biotechnology, advanced materials and energy technologies will be the fundamental driving force behind technological transformation. ”

The transformation in the field of advanced materials is also being accelerated largely by data-driven innovation. Due to graph neural networks, physics-based simulations, automated material modeling tools and adaptive simulation techniques, the material discovery cycle has accelerated and a data-driven approach to material development has replaced laboratory-focused, lengthy trial-and-error processes (WEF, 2025b). This transformation creates a strategic competitive advantage, particularly in areas such as energy-efficient thermal materials, battery technologies, thermal management of electronic systems and ultralight composites. At the same time, the convergence of biotechnology and materials science is enabling new bioproduction processes and accelerating the commercialization of sustainable, low-carbon footprint materials.

Spatial intelligence technologies also strengthen the integration of physical and digital environments. The fact that 31 billion micro-electromechanical system sensors (MEMS) are shipped worldwide in 2024 demonstrates the rapid scale growth of sensor technology (Info-Tech Research Group, 2025). The increasing computing power of these sensors, the ability of artificial intelligence models to run on-devices and the expansion of satellite-based positioning systems have made spatial intelligence-based applications more reliable and real-time. The fact that the number of active satellites exceeded 8,000

during the same period shows that space-based spatial data plays a critical infrastructure role in sectors such as agriculture, energy, insurance and logistics. Spatial intelligence, combined with robotic systems, digital twin technologies and three-dimensional mapping methods, offers high precision in areas such as digital twin modeling of production lines, monitoring of urban infrastructure and anatomical simulations in healthcare technologies.

Another pillar of technological transformation is next-generation energy technologies. AI-based demand management, smart grids that balance volatility in renewable energy production and next-generation battery systems have made energy systems not only more efficient but also more resilient and data-driven (WEF, 2025b). Smart grids optimize energy demand by processing real-time data, battery technologies combined with advanced materials offer higher energy density and longer lifespan and biotechnology creates new options for low-carbon biofuel production.

When all these technological fields are considered together, the fundamental characteristic of the technological transformation after 2025 is the establishment of an ecosystem structure where technologies interact with each other and create value. The WEF's 3C framework consisting of combination, convergence and compounding phases, provides a suitable analytical basis for understanding this process (WEF, 2025b). In the first stage, technologies combine to create integrated systems with new capabilities; in the second stage, sectors and value chains converge, giving rise to new product categories and economic areas; and in the third stage, standardization and cost reductions enable these technologies to create large-scale economic impacts. Therefore, all critical technologies, from artificial intelligence to biotechnology, advanced materials to spatial intelligence and energy technologies are parts of a whole that complement and reinforce each other. Artificial intelligence progresses dependently on advanced materials and semiconductor technologies, sensor networks provide the data infrastructure required by artificial intelligence, biotechnology uses this data infrastructure to create scalable biological production systems and energy technologies determine the energy efficiency and sustainability of this entire system. This interdependence makes technological convergence the most powerful driving force behind economic transformation after 2025.

1.4. The Evolution of New Industrial Policies

“ Industrial policy has now become more than just a tool for increasing production and productivity; it is a means of building multifaceted strategic capacity, ranging from technological dominance to supply chain security. ”

The transformation that industrial policies are undergoing globally today differs significantly from the industrial policy approaches of previous decades in terms of scope, scale and function. Geo-economic fragmentation which accelerated especially after 2022, rapid price drops in critical technologies, supply chain risks and the financing requirements of the green transition have made the return of governments to industrial policies a systemic necessity rather than a choice. In this new era, industrial policy has transformed into a multi-dimensional policy component that aims not only to increase competitiveness in specific sectors but also to simultaneously develop the infrastructure required for strategic independence, technological sovereignty, supply chain security, decarbonization and digital transformation.

The analysis in the IMF's October 2025 World Economic Outlook report regarding the return of industrial policies strikingly reveals the scale of this transformation. A sample policy simulation included in the report shows that imposing a 10% tariff on imports and subsidizing production by 12% increases investment and output in the short term but reduces overall factor productivity, puts pressure on the budget balance and lowers global prosperity in the long term (IMF, 2025a). The IMF's analysis emphasizes that the impact of industrial policies is not linear and that short-term increases in production must be considered in conjunction with long-term costs. Another IMF note dated 2025 states that industrial policy tools are powerful but costly; poorly designed interventions lead to distortions in resource allocation, unsustainable burdens on public finances and fuel a subsidy race between countries (IMF, 2025b). Therefore, industrial policies when used effectively can be a mechanism that strengthens strategic sectors but when poorly designed, they can become a costly burden that generates inefficiency.

One of the most concrete examples of this policy shift is the CHIPS and Science Act and the Inflation Reduction Act packages that the US enacted after 2022 (The White House, 2022a). The CHIPS Act includes a total stimulus package of \$52.7 billion USD; \$39 USD

billion of this is allocated to semiconductor manufacturing subsidies and \$13 billion USD to R&D and workforce development activities (National Institute of Standards and Technology, 2024). It has been decided that Intel will receive \$7.9 billion, TSMC \$6.6 billion and Micron \$6.1 billion in support during the 2024-2025 period. Interventions of this scale are being carried out in line with the U.S.'s goal to regain lost share in advanced logic chip production by 2030 and reduce its reliance on Asia in critical hardware supply chains. The Inflation Reduction Act, on the other hand, offers a very broad set of incentives for clean energy infrastructure, battery production, electric vehicles, grid modernization and carbon reduction technologies, creating a uniquely US “dual industry strategy” (The White House, 2022b). This strategy aims to both increase production capacity in clean technologies and establish an industrial foundation that aligns with climate goals.

On the other hand, the European Union is reshaping its industrial policies primarily around the axis of green transformation and strategic independence. The Green Deal Industrial Plan and the Net-Zero Industry Act (NZIA) aim for the European economy to have a globally competitive manufacturing capacity in net-zero technologies by 2030. NZIA aims to accelerate the commercialization of clean technologies and strengthen critical supply chains by ensuring that at least 40% of the European Union's annual net-zero technology installation needs are produced within the Union. However, the IMF's 2024 study on European industrial policies reveals that support packages provided by member states at the national level create tensions in terms of competition and integrity within the European Single Market and that inconsistencies exist between national instruments and common programs at the European level (Hodge et al., 2024). Another debate arose within the framework of the Emergency Competitiveness Plan, announced in 2025. This program includes a wide range of measures such as a €100 billion carbon reduction fund, lowering energy costs, simplifying bureaucratic processes and supporting the transformation of high-emission sectors such as automotive, steel and chemicals. However, debates about relaxing sustainability standards in some sectors show that Europe is in the midst of a challenging balancing act between the green transition and competitive pressures.

“ While the EU's net-zero industry policy aims to increase production capacity in clean technologies, it points to a challenging balance between competitive pressures and sustainability standards. ”

China's industrial policy approach offers a unique framework consisting of a combination of economies of scale, state control and strategic sector concentration. The IMF's World Economic Outlook 2025 estimates that China's industrial policy costs during 2011-2023 amounted to approximately 4% of GDP annually, representing a much larger scale of intervention compared to both the US and the EU (IMF, 2025a). China's enormous scale, particularly in solar panels, batteries, electric vehicles and telecommunications equipment, has made it a driving force in global pricing. IEA's World Energy Outlook 2025 data shows that costs have fallen to unprecedented levels due to a fourfold increase in solar panel production capacity over the past five years and China's continued dominant share in the lithium-ion battery supply chain (IEA, 2025b). This situation is both accelerating the spread of clean technology and making the industrial policy responses of the US and the EU more aggressive. This is because China's scale creates pressure not only in terms of price competition but also in terms of technological governance, standard-setting and supply chain dependencies.

A comparison of the industrial policy approaches of these three major economic actors reveals a complementary picture, although the size, direction and objectives of policy instruments differ. While the US is following a model heavily focused on fiscal stimulus to bring manufacturing back home, the EU is adopting an approach that centers on a regulatory framework, prioritizes green transition and seeks to preserve the integrity of the single market. China, on the other hand is expanding its production capacity through large-scale state support and is gaining a decisive position in critical links of global value chains. These differences can be summarized as follows:

- **USA:** Large-scale subsidies, attracting manufacturing to the country, technological sovereignty, supply chain diversification.
- **EU:** Regulatory framework, sustainability, single market integrity, green industry tools, carbon border regulations.
- **China:** Long-term planning, state-led technology and information dominance, leadership in scientific output/patent in critical technologies, vertical integration supported by economies of scale.

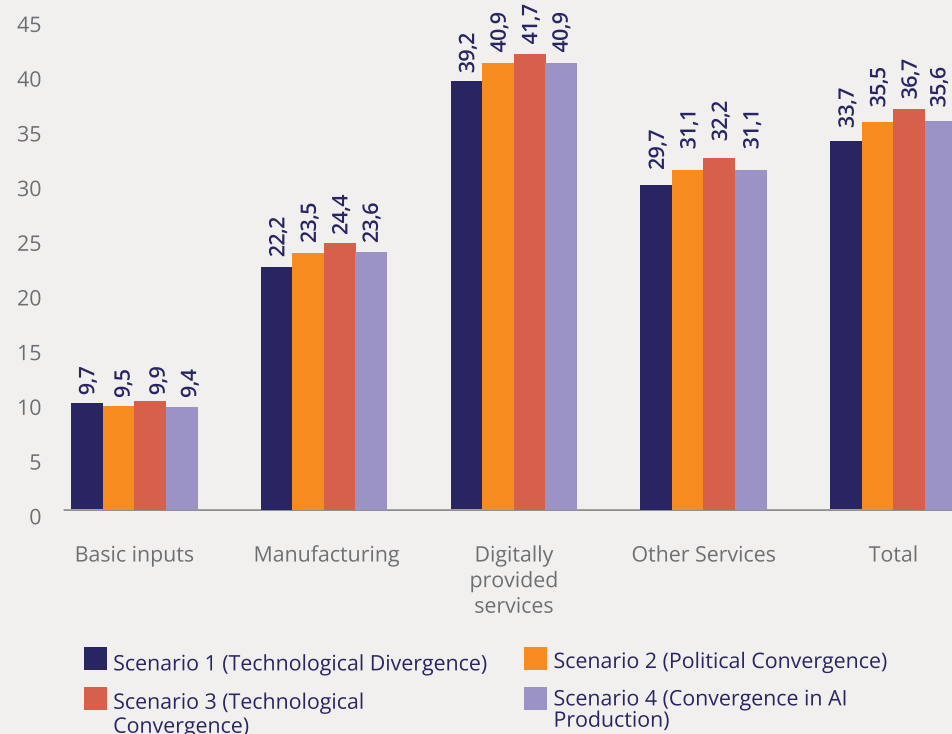
Another defining characteristic of this new wave of industrial policies is that it accelerates geo-economic fragmentation. The IMF notes that industrial policies are driving countries into a subsidy race, increasing local content requirements and tendencies towards reciprocal retaliation which in turn creates a risk of deepening fragmentation in the global trading system (IMF, 2025a). The World Economic Forum's Global Risks Report 2025 similarly identifies technology and trade wars among the most likely risks in the short and medium term; the report highlighted that undesirable consequences, particularly in cutting-edge technologies, systemic vulnerabilities stemming from artificial intelligence and the risk of information manipulation pose a threat to economic stability (WEF, 2025a). Under these conditions, industrial policies are no longer merely a tool for production and competitiveness but also a policy architecture used in geopolitical positioning, setting technology standards and managing strategic dependencies.

1.5. New Scenarios in Production, Technology and the Economy Towards 2030

“As we approach 2030, it has become imperative for low- and middle-income countries to focus not only on growth but also on productivity and technology-based structural transformations in their fight against poverty.”

As the global economy moves towards its 2030 target, it is entering a new era shaped by low growth and high uncertainty. According to the OECD Economic Outlook 2025, global growth is expected to decline from 3.3% in 2024 to 3.2% in 2025 and 2.9% in 2026; high tariffs, weakness in the investment pathway and increasing policy uncertainty are suppressing trade volume and capital formation (OECD, 2025d). The United Nations Department of Economic and Social Affairs' World Economic Situation and Prospects 2025 report paints a similar picture, highlighting that global growth will hover around 2.5% in 2025-2026, significantly below the 2010-2019 average of 3.2% (UN DESA, 2025). This outlook suggests that low growth could become permanent, making the fight against poverty, particularly in low- and middle-income countries, a much more complex task than in previous years. The International Monetary Fund's April 2025 World Economic Outlook further reinforces this framework with its narrative "Policy Uncertainty Tests Global Resilience," stating that despite falling inflation, increasing uncertainty, geopolitical risks and high debt levels are suppressing investment and weakening the growth outlook (IMF, 2025c). In such an environment, the determinants of the economic path towards 2030 are no longer just macroeconomic indicators but a multifaceted combination of technological diffusion, energy transition and geopolitical competition.

Figure 1.10. Expected Increase in Global Trade Due to Artificial Intelligence (% , 2025-2040)



Source: WTO (2025b). Note: The scenarios in the graph are modeled according to the degree to which the digital divide between countries closes. Scenario 1 (Technological Divergence) reflects the situation where the current digital divide persists; Scenario 2 (Policy Convergence) addresses the situation where low-income countries close the digital infrastructure gap. Scenario 3 (Technological Convergence) also includes increased AI usage efficiency; and Scenario 4 (AI Manufacturing Convergence) represents the most comprehensive growth where countries also equalize their AI service manufacturing capacities.

“While artificial intelligence has the potential to transform global growth, unless the digital gap between countries is closed, these gains will deepen inequalities in trade.”

The impact of technology, particularly in the context of artificial intelligence, is one of the main factors driving the 2030 scenarios in different directions. Analysis in the World Trade Organization's 2025 World Trade Report indicates that artificial intelligence has the potential to boost global trade by 34% to 37% and global GDP by 12% to 13% by 2040 (WTO, 2025b). However, the report also reveals that the distribution of these gains will vary according to the countries' "digital maturity" level under four different scenarios, the potential consequences of which on trade are presented in Figure 1.10.

- **Technological Decomposition (Scenario 1):** In this “double-speed” scenario (where technological development progresses at two different speeds, creating inequality), the current digital divide persists, high-income countries see a 14% increase in income from artificial intelligence while economies with limited capacity see this increase remain at 8%, deepening inequality.
- **Inclusive Convergence (Scenarios 3 and 4):** In this optimistic trajectory where countries are closing the gap in their digital infrastructure and artificial intelligence production capacities, the growth rate of low-income economies (15%) is catching up with developed economies; productivity and trade increases are spreading globally.

The report also warns that the realization of these growth scenarios depends on global cooperation. It is emphasized that in the event of a potential “fragmentation” in data regimes and security standards, disruptions in data flows could cause losses of up to 4.5% in global GDP, jeopardizing all the gains shown in the graph.

Looking at the energy and climate transition; the International Energy Agency's (IEA) World Energy Outlook 2024 and the International Renewable Energy Agency's (IRENA) Energy Transitions Outlook 2024 reports show that in all scenarios, energy demand is growing more slowly while clean energy technologies are scaling rapidly with installed solar capacity nearly quadrupling and manufacturing capacity sixfold (IEA, 2024; IRENA, 2024). However, the gap between the current policy path and the 1.5 degrees Celsius target is widening, creating significant uncertainties about the direction of the energy system towards the 2030s. The World Economic Forum's Global Risks 2025 report ranks climate change and natural resource scarcity risks at the top of its ten-year projections (WEF, 2025a). This outlook raises three possible energy-climate scenarios: an accelerated clean energy path leads to full utilization of clean energy production capacity, a gradual decline in fossil fuel investments and a significant cost advantage in renewable energy. In a mixed portfolio scenario, renewable energy expands simultaneously with LNG and other fossil fuels; in this case, global emissions remain constant but do not experience a significant decrease. In a rebound or lag scenario, however, policy setbacks, the return of fossil fuel subsidies and a high-interest rate environment slow clean energy investments and emissions may start to rise again towards 2030.

The social impacts of this economic, technological and energy transformation are creating a separate axis of transformation. United Nations and World Bank assessments indicate that in an environment of low growth and high uncertainty, if social protection infrastructures are not strengthened, the digital and green transformation could exacerbate inequalities, raising the risk of a “lost decade” particularly in low- and middle-income countries (UN DESA, 2025; World Bank, 2025). UNCTAD's 2025 Technology and Innovation Report reveals that an inclusive AI framework does not offer equal transformation opportunities for all countries due to deep gaps in infrastructure, data and skills; therefore, productivity gains from AI will not be distributed equally among societies (UNCTAD, 2025). The World Economic Forum's Global Risks 2025 report also states that technology-related risks are on the rise with digital surveillance, information manipulation and insecure data ecosystems putting pressure on democracies (WEF, 2025a). This picture shows that the economic benefits of technological transformation can only translate into broad-based prosperity if supported by a strong social protection framework, inclusive education systems and policies that reduce regional inequalities.

Four main scenarios for the global future extending to 2030 emerge when these multi-dimensional transformation axes are brought together. These scenarios consist of varying combinations of technology diffusion rates, the depth of the green transition and levels of geopolitical tension. In the first scenario with coordinated acceleration the green transformation progresses in line with net-zero targets, technological transformation spreads rapidly and geopolitical tensions remain manageable. In this scenario global productivity and trade increase, the energy transition accelerates and the digital divide between countries narrows relatively due to the widespread adoption of artificial intelligence applications. For Türkiye, this scenario points to a future where opportunities are increasing particularly in manufacturing, renewable energy and the digital sector where stronger integration into global supply chains is possible.

In the second scenario with a green but fragile path, technology diffusion and green transformation are strong but geopolitical tensions are increasing. Competition for critical minerals, security concerns in battery and semiconductor supply chains and political pressures on energy technologies are hallmarks. While clean energy investments may accelerate in this situation, costs can become volatile, energy security risks can increase, and global inequalities can deepen further. For Türkiye, this scenario presents opportunities in renewable energy and battery technologies, but it also represents a future where cost pressures and supply chain vulnerabilities may increase due to external dependence.

In the third scenario of conflictual stagnation, technology diffusion is limited, green transition is shallow and geopolitical tensions are high. In this scenario global growth stagnates, trade shrinks due to bloc formation and data regimes and security policies restrict technology flows. Emissions are not falling because of the slowdown in the

energy transition, and the global economy is trapped in a spiral of low growth and high uncertainty. For Türkiye, this scenario presents a framework where risks are intensified in terms of exports, energy costs and access to technology.

In the fourth scenario with the dual-speed world, technology and green transformation are rapid, but only occur in specific groups of countries. The gap widens between countries benefiting from AI investments and reduced clean energy costs and those with insufficient digital infrastructure and skills. In this case, global inequality deepens; average growth rates are relatively moderate, but the distribution is extremely asymmetrical. In this scenario, Türkiye is situated at an intersection possessing the potential to both break away from the emerging economies group and leap into the top league through the right policy choices. In particular, skilled human resources, digital infrastructure and investments in renewable energy are critical determinants in this scenario.

Table 1.1. Global Economic, Technological and Geopolitical Scenario Landscape Towards 2030

Scenario	Technology	Depth of Green Transformation	Level of Geopolitical Tension
Coordinated Acceleration	Full Deployment: Artificial intelligence and digital technologies rapidly spread to all countries; technological gaps between nations close	Full Compliance: Net-zero targets are achieved; Clean energy costs fall and investments increase globally	Low Risk: International cooperation is strong; trade wars decrease and a predictable environment is created.
Green but Fragile	High but Dependent: Technology spreads rapidly, but the risks of dependence on foreign sources for critical hardware and raw materials persist.	Fast and Aggressive: Green transformation is very rapid, but this speed leads to bottlenecks and cost pressures in supply chains.	High Competition: Fierce competition and tension arise over critical minerals and energy technologies.
Conflictual Stagnation	Limited and Fragmented: Technology transfer is hampered by firewalls; artificial intelligence only develops within specific blocks.	Slow and Insufficient: Fossil fuel dependence continues; green transition targets cannot be met due to global disagreements	High Tension: Trade wars, bloc formation and security concerns lock down economic relations.
Double Speed World	Asymmetric Development: Only developed countries benefit from technology; others fall behind in the digital divide.	Uneven Transition: Rich countries complete the green transition, while developing countries experience a lack of funding and technology.	Intermediate Level: There is no global conflict, but there is a disconnection between developed and developing countries.

The summarized key parameters of these four scenarios (Table 1.10.) indicate that the global economic order is evolving towards a complex framework characterized by the interaction of the pace of technological progress and green transformation with geopolitical balances, all within the context of the 2030 target. The capacity of countries to determine the direction of this transformation depends not only on their growth dynamics but also on institutional resilience, infrastructure investments, human resource policies and their ability to sustain international cooperation.

While all these scenarios present both opportunities and risks for Türkiye, the key factor determining which path will become reality is the holistic management of technology, energy and social policies. The coordinated acceleration scenario presents the best opportunities for Türkiye. The rapid spread of technology and the strengthening of the green transformation are compatible with Türkiye's strengths in manufacturing, digital services, defense and renewable energy. This scenario provides Türkiye with opportunities for deeper integration into global value chains, increased efficiency and a leap in advanced technology exports. For this to happen, however, there must be no delays in investments in artificial intelligence, data infrastructure and green industries.

In the green but fragile scenario, the clean energy transition continues to create advantages for Türkiye, but rising geopolitical tensions and dependence on foreign sources for critical minerals and battery technologies increase cost risks for the country.

Under these conditions, Türkiye is likely to become a strong player in renewable energy production, but it needs to manage supply risks in equipment and technology components.

A conflict-ridden stalemate scenario is the most unfavorable path for Türkiye. In this scenario, a contraction in global trade, slowdowns in technology flows and volatility in energy costs will put pressures on Türkiye's growth and export-oriented sectors. As access to critical technologies becomes more difficult and global uncertainty increases, capital inflows are likely to weaken. Therefore, this is the riskiest scenario in terms of both growth and social indicators.

The dual-speed world scenario presents both risks and opportunities for Türkiye. As technology and green transformation accelerate and this transformation becomes concentrated in certain countries, a period will emerge in which Türkiye's strategic choices will become critical. If Türkiye strengthens its digital capabilities, artificial intelligence applications, data governance and clean technology production capacity in a timely manner, it can leap to the top league; otherwise, it risks being left out of the transformation and becoming one of the countries where income disparity widens.

In general, the key message for Türkiye: In every scenario extending to 2030, the capacity to deploy technology, the financing of the green transformation and geopolitical risk management are the three strategic axes that will determine the direction of national performance.





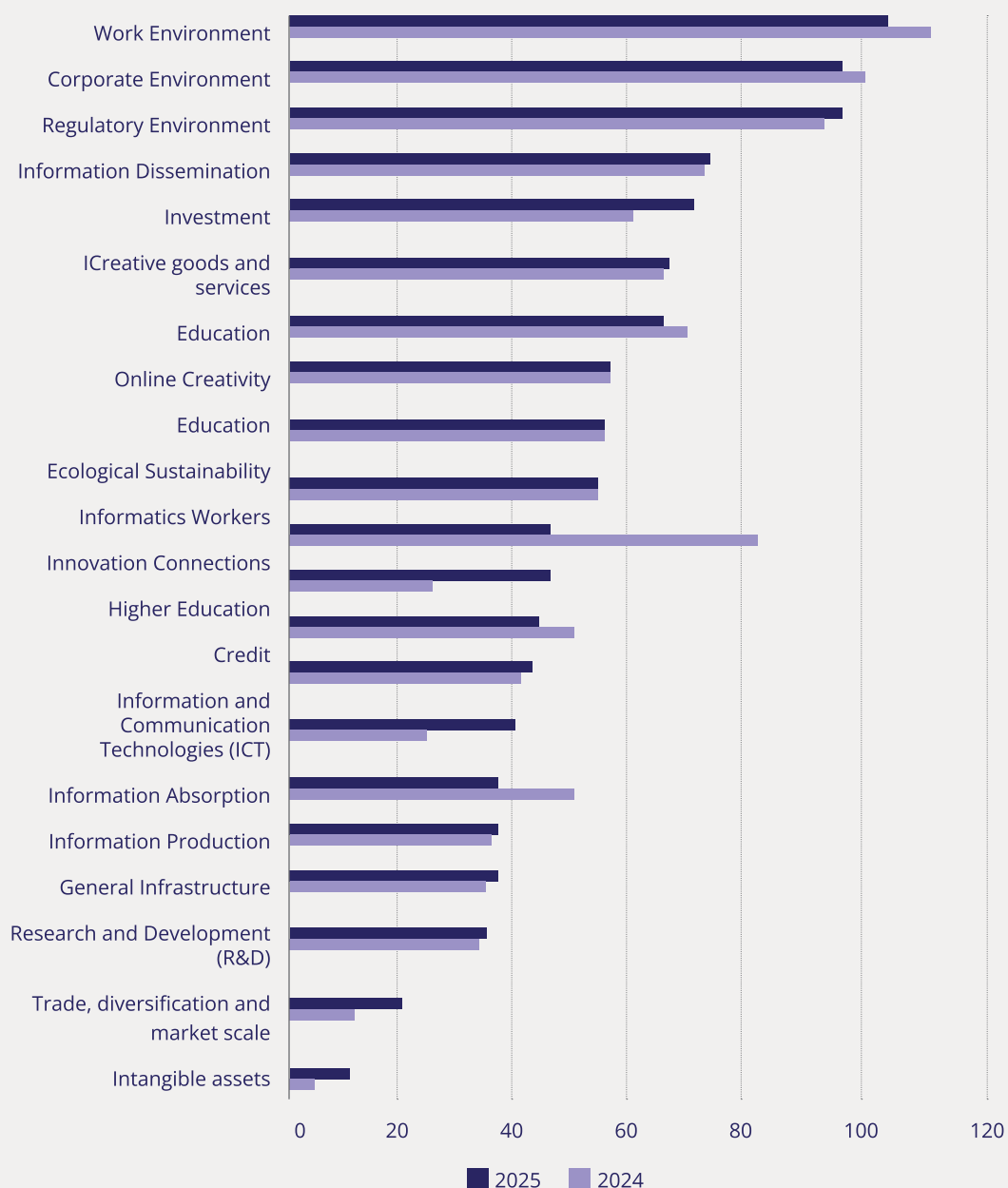
TÜRKİYE'S POSITION IN GLOBAL TECHNOLOGY INDEXES AND REGIONAL PERFORMANCE INDICATORS

2.1. Türkiye's Position in the Global Innovation Index (2025)

“ Türkiye continues its steady rise in global innovation competition, ranking as the third most innovative country among upper-middle-income economies, after China and Malaysia. ”

The Global Innovation Index (GII) 2025 data published by WIPO (WIPO, 2025) indicates a general improvement in Türkiye's global innovation performance in recent years, albeit with some fluctuations. In 2025, Türkiye was ranked 43rd out of 139 countries. While this position represents a six-place drop from Türkiye's historical best ranking of 37th in 2022 and 2024, the long-term trend shows that Türkiye has been on a steady climb since the 2010s. Indeed, since 2013, India, Vietnam and Türkiye have been the fastest-rising innovation drivers among middle-income economies and Türkiye has significantly increased its innovation score since 2019, managing to enter the top 40 countries for the first time in 2022. The fact that Türkiye rose from 51st place in 2020 to 37th place in 2022 underscores this achievement. Although Türkiye is projected to fall slightly below the 40% mark again by 2025, it maintains its position as the 3rd most innovative country among upper-middle-income economies after China and Malaysia. The report also states that Türkiye, when examined within the North Africa and West Asia region, ranks 4th regionally after Israel, Southern Cyprus and the United Arab Emirates.

Figure 2.1. Türkiye's Rankings in GII Fields in 2024 and 2025



Source: World Intellectual Property Organization.

Note: This is a ranking among 133 countries for which data is available for both years.

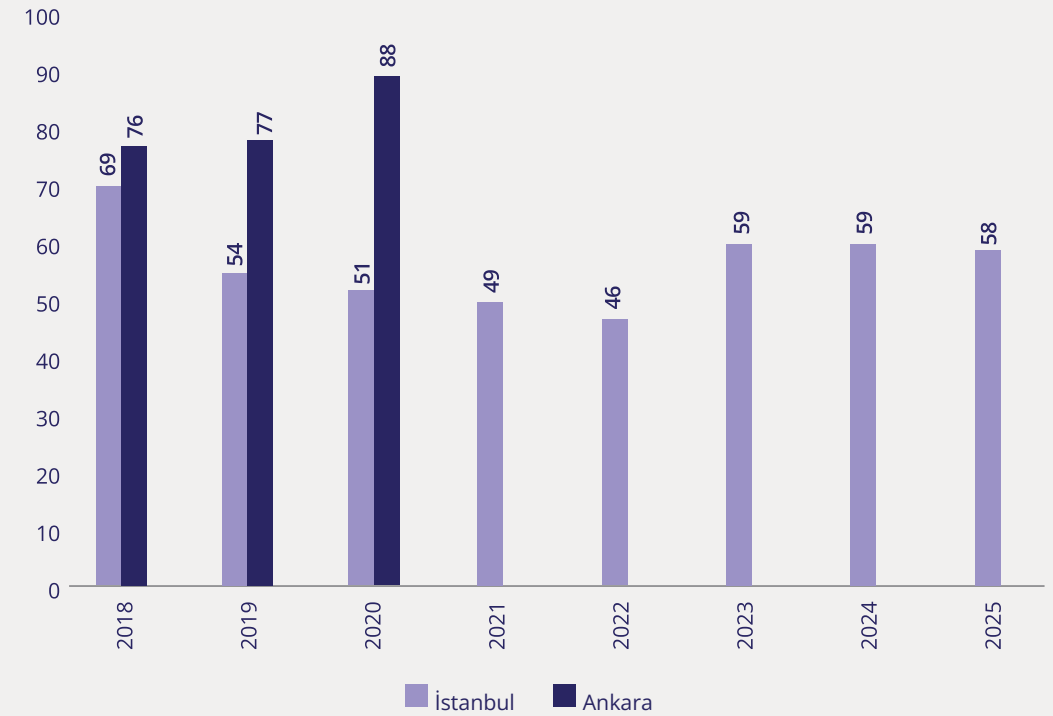
The GII 2025 Report also reveals the strengths and weaknesses of Türkiye's innovation ecosystem. Looking at the index components, Türkiye's best performance, as in previous years is seen in the creative output component. Although Türkiye ranks 30th out of 139 countries in this category, it is 14 places lower than its position last year. Türkiye ranks highly, particularly in terms of commercially viable creative products and brand/industrial design outputs. On the other hand, in the "Institutions" component which includes elements such as the institutional, regulatory and business environment, Türkiye is still far behind. As shown in Figure 2.1, Türkiye is among the countries with weak performance in three areas within this component. When examined on a field-by-field basis, it is observed that Türkiye has made the greatest progress in innovation connectivity (35 places), knowledge absorption (13 places) and business environment (7 places) in 2025. However, it is noteworthy that Türkiye continues to rank in the upper-middle ranks in the first two of these areas and among the weakest countries in the business environment. The fastest declines occurred in the areas of information impact (20 places), information and communication technologies (15 places) and investment (10 places). The first two of these areas were among the top four areas in which Türkiye performed best the previous year. The decline in all four of the top areas where the country performed best in the 2024 rankings indicates that Türkiye is struggling to maintain its strengths.

The GII findings highlight the role of high-tech manufacturing and exports, industrial diversification and international trade connections in Türkiye's recent growth. According to the WIPO (2025) report, although Türkiye experienced some slowdown in 2025 due to certain macroeconomic challenges, it maintained its position close to the top 40 in 2025 due to its industrial infrastructure and strength in high-tech product trade. According to the report, Türkiye is one of the few middle-income economies, along with China (10th), India (38th) and Vietnam (44th) that manages to be among the top 50 in the index ranking. Increased technological capabilities and digitalization investments, particularly in sectors such as defense, aviation and electronics are cited as factors supporting this rise. Indeed, Türkiye has been evaluated among the countries that have demonstrated above-expected innovation performance as of 2025; it has been defined as a middle-income economy that has increased its innovation capacity due to improvements in education, investment in digital infrastructure and strengthening public-private partnerships. In summary, Türkiye has continued to demonstrate a profile of a country that outperforms its innovation outputs compared to its innovation inputs. All these findings show that despite Türkiye's shortcomings in areas such as a suitable institutional environment, highly educated human resources and R&D expenditures, it can produce higher commercialization and innovation outputs than expected with its current input level.

“ Istanbul's rise in the global innovation league and Ankara's R&D-supported position demonstrate that innovation in Türkiye is spatially confined to a narrow area. ”

GII data on the geographical distribution of Türkiye's innovation ecosystem also reveals regional innovation clusters. According to the "Science and Technology Clusters" ranking published within the scope of GII, Istanbul is ranked 58th among the world's leading innovation centers in 2025. This index measures the capacity of cities based on scientific publication and patent production and shows that Istanbul has achieved a level of science and technology intensity that can compete with cities such as Zurich, Barcelona and Brussels. Ankara was among the top 100 clusters in the 2018-2020 period but later dropped out of the list. It is evaluated within the scope of the GII clusters list and is seen as a remarkable innovation center worldwide owing to its research universities such as METU and Bilkent and its defense industry R&D clusters. The GII 2022 report highlighted that Istanbul and Ankara host two significant science and technology clusters. This suggests that innovation activities in Türkiye are concentrated in certain major cities and therefore, increasing innovation capacity in other regions is crucial. The GII 2025 report also addresses this issue, revealing that the innovation ecosystem in Türkiye is geographically confined to a limited area and that differences in technology concentration between provinces are significant. These differences necessitate a reassessment of regional development policies and industrial strategies with a focus on technological transformation.

Figure 2.2. Ranking of Ankara and Istanbul in the Top 100 Science and Technology Clusters



Source: World Intellectual Property Organization.

Note: Ankara has not been included in the top 100 list since 2020.

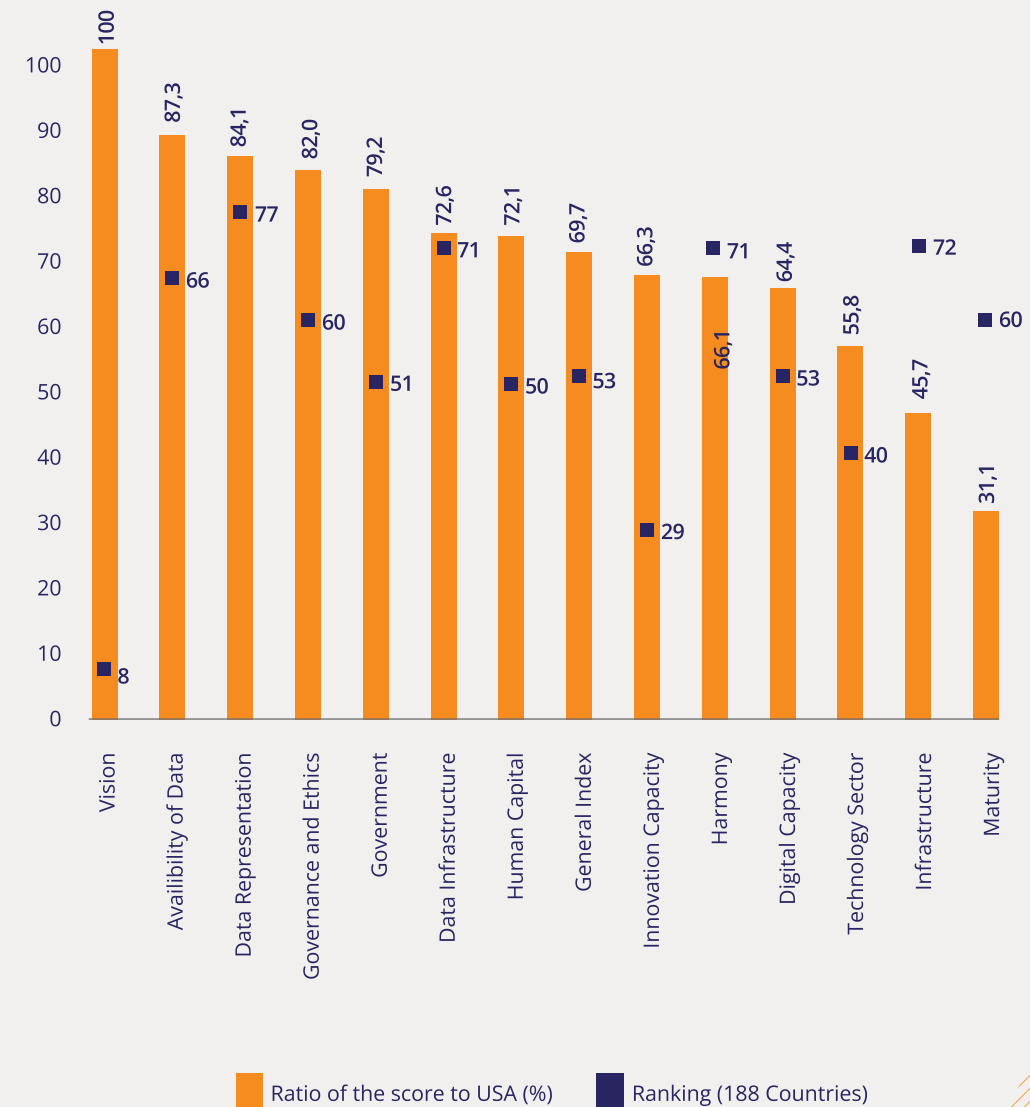
2.2. Türkiye's Position in Artificial Intelligence Indices

In various indices that assess artificial intelligence (AI) competence and readiness on a global scale, Türkiye generally ranks in the middle, lagging considerably behind the leading countries. However, a recent trend of improvement in some indicators is noteworthy.

“ Although Türkiye has a strong AI vision, its data infrastructure, human resources and corporate application capacity are limiting the development of the AI ecosystem. ”

According to the Oxford Insights 2024 Government AI Readiness Index, Türkiye ranks 53rd out of 188 countries in terms of institutional and infrastructural readiness for AI. Türkiye's overall score on this index is 60.63 which is only 69.7% of the score of the top-ranked USA. Türkiye has dropped six places in the rankings compared to the previous year (47th in 2023). Looking at the sub-components of the preparedness index, Türkiye is relatively well-positioned in the vision dimension of the public sector component and the innovation capacity dimension of the technology sector component (ranked 8th in the former and 29th in the latter). In four of the eight dimensions other than these, Türkiye ranks between 50-60 while in the other four, it performs between 66-77 places. The fact that Türkiye ranks eighth in the "vision" dimension (one of the four areas constituting the public sector component) and 53rd, 60th and 71st in the other three areas indicates a discrepancy between vision and implementation. On the other hand, the component that most negatively impacts Türkiye's performance in this index is the "data and infrastructure" component where it ranks 71st. This indicates that Türkiye lags behind developed countries in terms of broadband internet access, data center capacity and information and communication technology investments. On the technology sector side, similar to the public sector component, it is noteworthy that while the innovation capacity is high, the country exhibits an average performance in terms of the human resources and maturity dimensions required to utilize this capacity. All these findings indicate that Türkiye needs improvement in terms of public policies and investment levels to support the artificial intelligence ecosystem.

Figure 2.3. Türkiye's Public Sector Artificial Intelligence Readiness Index 2024 Performance



Source: Oxford Insights.

The Stanford AI Index 2024 Report, prepared by the Stanford University Institute for Human-Centered Artificial Intelligence (HAI), provides a detailed overview of Türkiye's AI capabilities. Based on 42 indicators, the report's assessment places Türkiye 31st out of 36 countries in 2023. This performance means Türkiye has fallen two places compared to its rankings in 2022 and 2023. When the 2023 performance is examined, it is seen that the country is pulled back due to the "responsible artificial intelligence" component where Türkiye ranks last and the "infrastructure" component, where it ranks second to last. The fact that the areas that stand out most for Türkiye are "public perception" and "the existence of a national artificial intelligence strategy" actually indicates that the country has embraced artificial intelligence socially and politically but has not been able to reflect this in policy applications, academia and real sector outcomes.

According to the same report, Türkiye has demonstrated remarkable progress particularly in the fields of robotics and engineering capabilities. For example, while the number of industrial robots installed decreased in countries such as the USA, China, Italy, Japan and France during the 2022-2023 period, it increased by 15% in Türkiye. This data supports the rapid adaptation of the Turkish manufacturing sector to automation and AI-assisted production technologies. The 198% increase in AI skills between 2016 and 2024 demonstrates the strengthening capacity to train the human capital required for AI. However, the report also highlights that the net migration of AI skills, as mentioned in last year's report, continues to be one of Türkiye's prominent problems. Among the 48 countries for which data is presented in the report, Türkiye is the country with the highest net outflow of AI skills as of 2024. The report also reveals that Türkiye's contribution to advanced artificial intelligence research remains limited. While the US has developed 109 models and China 20, the lack of a model in Türkiye indicates that our country does not have a significant output in developing large-scale artificial intelligence foundation models. On the other hand, Türkiye lags far behind the leading countries in terms of private sector AI investments. Indeed, according to 2023 data, private sector AI investments were \$67.2 billion in the US, \$7.76 billion in China, \$3.78 billion in the UK and \$1.39 billion in India while this amount was only \$151.2 million in Türkiye. In other words, Türkiye lags behind leading countries in terms of investments relative to its income. The report's findings also imply that Türkiye needs to strengthen its policies and governance regarding AI. Türkiye needs to translate its national AI strategy into concrete actions by increasing R&D investments, establishing a data sharing infrastructure and ensuring that talented researchers remain within the country.

Another comparison with a broader scope at the country level is the Global AI Index prepared by Tortoise Media (Tortoise Media, 2024). This index, which brings together 122 different criteria (investments, research outputs, technology use, etc.) in three main dimensions (implementation, innovation, investment), comprehensively evaluates the artificial intelligence capacity of countries. According to the latest 2024 results, countries

like the US, China and Singapore top the list with the US's leadership in research and generative AI infrastructure being particularly noteworthy. Türkiye is not among the top 20 in this index, ranking 34th out of 83 countries in terms of overall score. In this assessment, Türkiye currently has a limited weight in terms of total investment and output in artificial intelligence, placing it only in the second group in the global AI race. However, it is frequently emphasized that Türkiye could rise in the rankings if it develops publicly supported AI strategies, encourages the use of AI in the private sector and participates in international collaborations (Tortoise Media, 2024). Looking at the components of the Global AI Index, the two areas that most significantly lowered Türkiye's ranking are "infrastructure," where it ranked 62nd out of 83 countries and "commercial," where it ranked 55th which focuses on the level of AI-based entrepreneurial activity, investment and business ventures.

In summary, current global AI indices indicate that Türkiye is underperforming its potential; however, human resources and developments in certain sectors are considered promising and it is believed that a leap forward in this field can be achieved with the right policies.



“ Despite increasing AI capabilities, talent migration and limited contributions to advanced AI research make it difficult for Türkiye to establish a lasting advantage in the technology race. ”

Another important observation regarding Türkiye's artificial intelligence ecosystem is the significant digital divide between sectors and regions within the country. OECD studies reveal that the adoption rate of artificial intelligence and digital technologies varies considerably between regions and sectors. Regions with advanced innovation ecosystems and skilled workforces integrate artificial intelligence much faster while traditional sectors and underdeveloped regions fail to keep pace (Kergroach and Héritier, 2025). For example, while 39% of large companies in the OECD use artificial intelligence technologies, this rate is only 12% in small firms; similarly, the rate of artificial intelligence adoption exceeds 25% in information-intensive sectors such as information and communication but is much lower in manufacturing and some rural areas. This situation indicates that the gap is widening between large, "early adopter" firms and lagging SMEs and that some regions may fall behind in digital transformation. Indeed, the OECD study (Kergroach and Héritier, 2025) emphasizes that "the most innovative regions are the fastest adopters of artificial intelligence," and states that regions with strong R&D infrastructure (for example, Southern Denmark in Northern Europe) made the biggest leap in AI use in the 2023-24 period. In this context while Türkiye's National Artificial Intelligence Strategy, announced in 2021 is an important step, the implementation phase of the strategy should prioritize the digital transformation of SMEs, the development of the data ecosystem and the training of human resources necessary for artificial intelligence in regions with high potential (Kergroach and Héritier, 2025; Republic of Türkiye Ministry of Industry and Technology, 2021).

“ While Türkiye lags behind the US and China in AI and advanced technologies, it can form a significant force in critical technologies together with the European ecosystem. ”



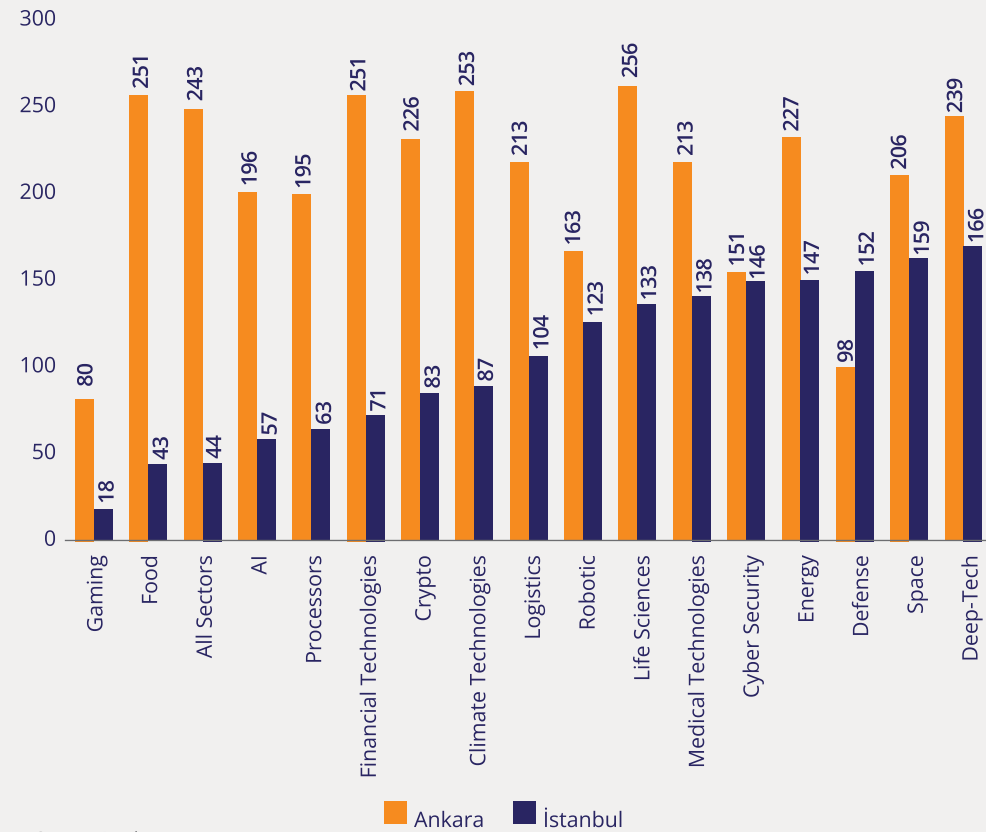
Finally, the Harvard Kennedy School Belfer Center Critical and Emerging Technologies (CET) Index 2025 results which compare national capacities in artificial intelligence and critical technologies on a geopolitical level, also offer a striking perspective on Türkiye's position. The results of 25 countries revealed that the US and China have a clear advantage in critical areas such as artificial intelligence, biotechnology, satellite technologies and quantum computing with European countries following closely behind. Türkiye has been evaluated as part of the European group in the CET Index and is among the countries contributing to Europe's technological total. According to the report's findings when the technological capabilities of European countries (including Türkiye) are combined, the continent's total score is approximately half that of the US and two-thirds that of China. This shows that countries like Türkiye can only become a meaningful technological power within broader alliances, not on their own. When viewed on a sectoral basis, the CET Index shows that Europe is the third global power in artificial intelligence, biotechnology and quantum technologies, behind the US and China. Although Türkiye has achieved unique successes, particularly in defense technologies and unmanned aerial vehicles, it is still in a "follower" position in the overall AI and advanced technology competition. This situation highlights the importance of Türkiye accelerating its national technology development initiatives and participating more effectively in international technological collaborations.

2.3. Türkiye and its Provinces in Technology Ecosystem and Startup Indices

In addition to global innovation rankings, indices focusing on entrepreneurship and technology ecosystems also reveal the performance of Türkiye and especially its major provinces. In the early 2020s, Türkiye began to attract attention in its region with increasing venture capital investments and unicorn outbursts; this trend was also reflected in global ecosystem reports.

“ With its rapidly increasing number of unicorns and the size of its venture capital, Türkiye has become one of the fastest-growing economies in the global technology ecosystem. ”

Figure 2.4. Ankara and Istanbul's Dealroom Global Tech Ecosystem Index 2025 Rankings



Source: Dealroom.co.

According to the Dealroom Global Technology Ecosystem Index 2025 Report, Türkiye's technology startup ecosystem has shown remarkable growth in recent years and has entered the top 5 rising ecosystems globally (Dealroom, 2025). Dealroom's analysis, covering 69 countries and 288 cities, specifically identifies Istanbul as a very successful province. Indeed, according to the report, Istanbul will be the second best in the world in its category by 2025. This statement demonstrates that Istanbul ranks among the top in terms of developing ecosystems and has become a global center of attraction. The same report also states that Türkiye's startup ecosystem has risen to 3rd place among globally emerging ecosystems. This remarkable rise is attributed to the increasing number of Turkish unicorns and the rapid maturation of the entrepreneurial ecosystem. According to most recent data, there are 6 unicorn startups based in Istanbul including Getir, Trendyol, Peak Games, Dream Games, Hepsiburada and Insider. The total value of Istanbul's startup ecosystem has reached 12.9 billion USD. The fact that total venture

capital investments in startups in Istanbul have exceeded 6.4 billion USD in the last four years alone, surpassing the global average, demonstrates that the ecosystem is gaining depth and scale. Early-stage investments in Istanbul have been measured at a high score of 8 out of 10 and the average exit time for startups is stated to be 9.3 years which is shorter than the global average. Although Istanbul ranks 44th among all cities according to the 2025 results, these figures reveal that Istanbul is rapidly progressing towards becoming not only a regional but also a global technology hub.



Turkish Aerospace Industries

When we look at the position of Ankara, Izmir and other cities in the technology ecosystems, we see that they make significant contributions although not on the same scale as Istanbul. In the Dealroom 2025 report Ankara is ranked 243rd. Figure 2.4 presents the rankings representing the development of ecosystems in various technology sectors for Ankara and Istanbul. The study compared 288 cities and Ankara is among the top 100 provinces in both defense and gaming facilities. Of the two sectors mentioned, gaming sector stands out as the most successful sector in Istanbul (ranked 18th). On the other hand, it is noteworthy that Ankara has a clear advantage over Istanbul in the field of defense. However, Istanbul differs from Ankara in terms of sectoral diversity in the technology field. In seven of the sixteen technology sectors covered by the study, Istanbul is among the top 100 ecosystems while Ankara has achieved this success in only two sectors.

In Dealroom data Ankara has traditionally been a hub for defense industry companies. With its defense-related startups, cybersecurity firms and research companies in technoparks, Ankara is particularly strong in military technologies, unmanned systems and electronics. Undeniably, defense and aerospace technologies produced in Ankara constitute a significant portion of Türkiye's high-tech exports. According to Turkish Statistical Institute (TÜİK) data, as of 2024, Türkiye's defense and aerospace industry exports reached a record high of 6.1 billion USD, with the majority of this coming from Ankara-based companies (TÜİK, 2025). Companies like ASELSAN, TUSAŞ (TAI) and Roketsan along with numerous startups within the METU Technopark are accelerating Ankara's ecosystem. In particular, success in unmanned aerial vehicle (UAV/UAS) technologies has made Ankara one of the leading centers in the world in this field. As a reflection of this, "weapons and ammunition" and "aviation and aerospace vehicles" are the leading categories in Ankara's high-tech product exports, showing remarkable increases in recent years. However, the difference in the diversity of technology sectors between Istanbul and Ankara primarily indicates that the knowledge generated in Ankara in the defense sector has not been sufficiently disseminated to other sectors. Secondly, the fact that Ankara's defense capacity largely stems from state-owned companies may limit the city's attractiveness for investment in other technology sectors. It is important for Ankara to both become more prominent in the defense sector and to be supported with strategies that will facilitate the development of an ecosystem in non-defense sectors.

“ Izmir, with its renewable energy, agriculture and health technologies and Bursa, Kocaeli and Eskişehir, with their sector-specific R&D capabilities, are centers that contribute to the regional technological diversity of Türkiye. ”

When we look at Izmir, despite its strong industrial infrastructure and export potential, the province lags behind Istanbul and Ankara in the technology entrepreneurship ecosystem. However, Izmir has the potential to make a breakthrough, especially in renewable energy technologies, agricultural technologies and the recently developing health technologies. Technoparks established around Izmir Institute of Technology and European Union projects offer steps towards increasing the city's innovation capacity. While Bursa stands out among other Anatolian cities with its R&D capabilities in automotive and machinery manufacturing; Kocaeli (Gebze), with institutions such as TÜBİTAK Marmara Research Center and the Informatics Valley is another innovation hub in the Marmara Region. Owing to its expertise in aviation and rail systems, Eskişehir is another province where

high technology accounts for a high percentage (34%) in the total of the province's exports. Similarly, some smaller provinces like Adıyaman have exceeded 25% in high-tech export shares, particularly in herbal and chemical-based products used in medicine and pharmacy. However, since the total export volumes of these provinces are limited, their impact on the high-tech economy on a national scale is relatively small. In general, Türkiye's high-tech production and high-tech exports are geographically concentrated in two provinces: As of 2024, 81% of Türkiye's total high-tech exports originate solely from Istanbul and Ankara. Ankara alone accounts for 20% of Türkiye's high-tech exports with approximately US\$1.7 billion. Meanwhile, Istanbul makes the largest contribution with a share exceeding 60%. When Istanbul, Ankara and Eskişehir are excluded, the total contribution of the other 78 provinces is only around 12%. This uneven distribution shows that Türkiye's manufacturing industry exports are still predominantly medium-high technology-oriented and that real progress in high-technology production is limited to only a few centers (ASO, 2025).

“ Ankara lags behind Istanbul in technological diversity because its strong R&D capacity in defense has not been sufficiently extended to other sectors. ”

When examining the sectors that stand out in Türkiye's overall technology ecosystem success, distinct advantages are evident in areas such as gaming, e-commerce, financial technologies (fintech) and logistics. The digital gaming sector, in particular, has become an area where Türkiye is globally competitive and attractive. In the first half of 2025, a significant portion of foreign-investment startup investments in Türkiye were directed towards gaming companies; for example, 7 out of 17 investment rounds involving foreign investors were in the gaming sector. This demonstrates the international confidence placed in the Turkish game development ecosystem. Following success stories like Peak Games and Dream Games, numerous game startups received investment or were acquired from abroad at high valuations in 2022 and 2023.

On the other hand, e-commerce and new retail technologies are also areas where Türkiye is excelling. The country's demographics, high internet and smartphone penetration (mobile broadband subscriber density at 83% in 2023) and geographical location have enabled the rapid scaling of digital marketplace models. In this context, e-commerce platforms like Trendyol and Hepsiburada, as well as innovative fast delivery startups like

Getir have not only grown in Türkiye but have also attracted the attention of global investors, reaching unicorn status. According to Dealroom data, Türkiye has a much higher concentration than the MENA (Middle East and North Africa) average in the fields of foodtech, home living and fashion technology due to influence of these companies. Given that Getir and Trendyol alone have accounted for the largest share of venture capital investments made in the last five years, Türkiye's venture capital portfolio stands out compared to other countries in the region. This development suggests that, looking ahead, Türkiye could become an innovation hub specializing in specific sectors.

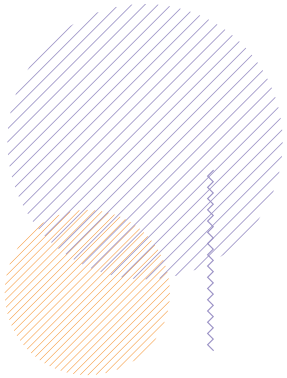
2.4. Performance in Key Technology Indicators for 2024-2025 and Developments by Province

“Despite the increase in high-tech exports, Türkiye's export share remains low and its high import dependency makes a structural technological transformation inevitable.”

To evaluate Türkiye's recent performance, it would be useful to look at key indicators such as high-tech production, trade, R&D investment rate, patent and intellectual property output, digital infrastructure and human resources. While a generally positive upward trend is observed in these indicators, there is still a way to go to reach the desired levels in international comparisons.

Exports of High-Tech Products:

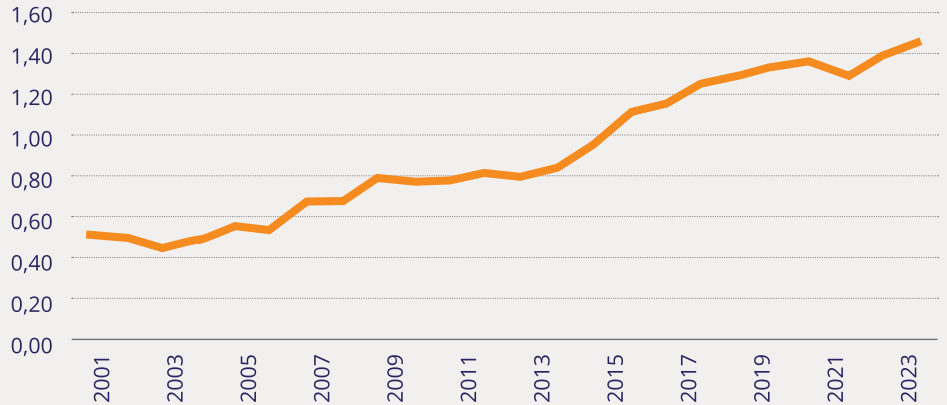
In 2024, the share of high-tech products in Türkiye's total merchandise exports was 3.6%. While this rate indicates a slight increase compared to previous years, it is still behind many developed and developing countries. While the share of high-technology exports in the total is 36% in South Korea, 51% in Malaysia and 20% in Hungary (UNCTAD, 2024), the fact that it remains in the 3-4% range in Türkiye indicates that the technological intensity of our manufacturing industry is limited. However, due to the momentum gained in sectors such as the defense and aerospace industries in recent years, the volume of high-tech exports has increased significantly. High-technology exports have increased to the 8-9 billion USD range as of 2024 in comparison to 5.5 billion USD in 2022 (TURKSTAT, 2025a). As mentioned above, the majority of this increase originated from Ankara and



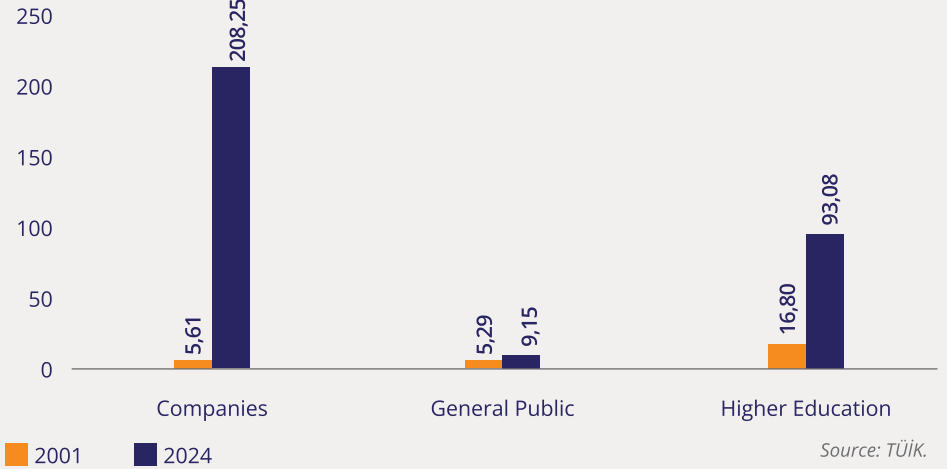
Istanbul. In particular, Ankara's exports of defense industry products and Istanbul's exports of electronics and IT products saw a surge during this period. On the other hand, imports of high-tech products continue to increase; especially in medical devices and pharmaceuticals our import dependency remains high. In 2024, imports of "medical and surgical devices" exceeded 800 million USD despite the decrease in the impact of the pandemic while imports of "aviation and aerospace vehicles" continued their upward trend. These figures show that Türkiye continues to have a foreign trade deficit in high technologies and underline the need for structural transformation. In summary, although there has been a recent recovery in high-tech exports, the low share of this sector within the total amount and the dependence on imports make it critically important to continue implementing policies that will increase added value in this area.

Figure 2.5. Development of R&D Indicators in Türkiye

Ratio of R&D expenditures to GDP (%)



Full-time equivalent R&D human resources (thousands of people)



“ Türkiye's current rate of 1.46% achieved through rapid increase in R&D spending shows that private sector investments need to be much stronger for a leap forward in technological competitiveness. ”

Research and Development Intensity (R&D Expenditures):

The ratio of R&D expenditures to national income is one of the most fundamental indicators of technological development. Türkiye has shown steady growth in this area over the last 5 years and the ratio of R&D expenditures to GDP has increased from 1% to 1.46% (Figure 2.5). According to TÜİK data, gross R&D expenditure reached 651.8 billion TL (approximately 19.9 billion USD) in 2024 (TÜİK, 2025b). In the financing structure of R&D expenditures, the private sector ranks first with a share of 53.8% while the public sector accounts for 30.4% and higher education for 12.9%. This distribution shows that the private sector is increasingly becoming the driving force of R&D. Accordingly, private sector R&D spending reached 350 billion TL in 2024 and 52.7% of this was carried out within R&D centers. Looking at it by sector, it is seen that 46.9% of R&D expenditures in the manufacturing industry are carried out by high-technology manufacturers. Significant gains have also been made in terms of R&D human resources: The number of full-time equivalent R&D personnel reached 310,473 in 2024 with 67% employed in the private sector. The tenfold increase in R&D personnel from just 29,000 in 2002 demonstrates the expansion of Türkiye's scientific and engineering capacity. In particular, the increase in the proportion of researchers with doctoral degrees to 30.6% of the total R&D personnel (21.2% on a full-time equivalent basis) highlights the development of advanced research capabilities. However, Türkiye's R&D intensity is still well below the OECD average (approximately 2.7%). Indeed, the "Türkiye Century" goals announced in 2024 include increasing the R&D/GDP ratio to 2% by 2028 (Industry and Technology Strategy, 2024). In this context, recent policies such as the expansion of Technoparks, the broadening of TÜBİTAK support programs and incentives for research personnel have been introduced. Maintaining such policy agenda and significantly increasing private sector R&D investments are crucial for achieving Türkiye's strategic plans.

“ Despite the increase in patent indicators, Türkiye's intellectual and industrial property rights ecosystem remains both spatially limited and has not yet matured sufficiently in terms of producing high-quality patents at the level of global competition. ”

Patent and Intellectual Property Outputs:

Another outcome of innovation is the manifestation of intellectual property, such as patent applications, utility models, trademarks and design registrations. Domestic patent applications in Türkiye have shown a general upward trend since 2013. According to data from TURKPATENT and the Trademark Office, a total of 10,186 domestic patents were filed in 2024 and since 2022, domestic patent applications in the country have exceeded foreign patent applications. The number of domestic patent registrations showed a continuous increase until 2022 but has stagnated in the last two years. The fact that the number of domestic patent applications, which was only 685 in 2004, has now exceeded 10,000 presents a concrete indicator of the increase in innovation capacity (TURKPATENT and Trademark Office, 2025). In the last 20 years, annual patent registrations in Türkiye have increased 49 times. Despite these developments, Türkiye still holds a modest position in international comparisons. For example, according to WIPO's World Intellectual Property Indicators 2025 Report, China ranked first in the world in 2024 with 1.8 million patent applications while the US had approximately 502,000 and Japan with 419,000 applications (WIPO, 2025b). Therefore, maintaining the upward trend of recent years and developing higher quality and internationally valid patents remains important. Another dimension of patent data is its geographical and institutional distribution. In 2024, the distribution of domestic patent applications by provinces showed that Istanbul, Ankara, Kocaeli, Bursa and Izmir ranked in the top five. These provinces respectively accounted for 37.8%, 18.1%, 7.2%, 4.6% and 4.3% of the total domestic patent applications. In other words, the fact that these five provinces constitute 72% of the total patent applications in the country is another indicator of the spatial distribution problem of technological activities. The reality of the majority of patents concentrating in a small number of large provinces and companies points to the need to build a more widespread and inclusive innovation ecosystem. Policies such as simplifying patent processes, strengthening university-industry collaboration and increasing intellectual property awareness among SMEs should continue.



“ Although Türkiye has made significant progress in digital infrastructure, it lags behind competitive countries in strategic areas such as high-speed connectivity, 5G transition, data center capacity and a qualified digital talent pool. ”

Digital Infrastructure and Talent:

Most technological development indices also include indicators such as digital infrastructure (internet access, 5G capacity, data centers, etc.) and talent pool (especially graduates, researchers and engineers in STEM fields). While Türkiye has made progress in these areas recently, it needs to increase its investments to avoid falling behind its competitors. When internet and mobile penetration is examined, it is seen that as of 2024 the internet user rate in Türkiye has reached 82% and smartphone penetration has reached 77% (Kemp, 2025). Mobile broadband subscriber density increased to 87 subscribers per 100 people in 2023 (BTK, 2025). With the widespread adoption of 4.5G service, mobile internet speed has caught up with the global average but the transition to 5G technology is still in the pilot phase and although large-scale 5G service arrived in countries like the United Kingdom in 2019, it is still not available in Türkiye. On the fixed broadband infrastructure side, although the number of fiber subscribers has exceeded 5 million, household penetration is at around 20%, which is below the OECD average. These indicators highlight the need for a breakthrough in digital infrastructure. High-speed and low-latency communication infrastructure across the country remains critical for data-intensive technologies such as artificial intelligence. Although Türkiye has the potential to become a hub in the region in terms of data centers and cloud infrastructure, large-scale data center investments have remained limited to date. The Information and Communication Security Circular which came into effect in 2024 is expected to encourage domestic data center investments by mandating the retention of public data within the country.

In terms of human resources, the data mentioned in previous sections shows that Türkiye is rapidly increasing the number of graduates in engineering and science fields. However, improvements are needed in terms of quality to ensure that graduates acquire competencies at international standards and participate in the R&D ecosystem. Brain drain remains a significant problem for Türkiye, particularly in the fields of artificial intelligence and information technology expertise. There has been some improvement

in recent years because of TÜBİTAK's brain drain remigration scholarships, international researcher attraction programs and increasing salary offers from the private sector. Nevertheless, the tendency of Turkish researchers and software developers to go abroad still continues. Thus, structural steps should be taken to retain talent in the country, improve working conditions and attract international talent.

In conclusion, Türkiye's performance and trends for the 2024-2025 period show a complex situation with a combination of partial improvements and ongoing structural problems. In global innovation and technology indices, Türkiye is now referred to as an "emerging player" and ranks in the upper end of the middle-income group. Positive trends such as the development of the startup ecosystem, the contribution of the defense industry to technology exports and increased R&D investments are noteworthy. However, there are significant areas for improvement, such as insufficient R&D spending compared to leading countries, the risk of lagging behind in digital infrastructure, a trade deficit in high-tech products and a regional innovation gap. If Türkiye continues comprehensive reforms and investments in these areas within the framework of its National Technology Initiative vision, it is possible for it to further improve its position in global technology indices in the coming period. The situation as of 2025 clearly shows that Türkiye's innovation ecosystem is gaining momentum but making this momentum sustainable requires political stability, training qualified human resources, increasing resources allocated to R&D and developing international collaborations. Steps taken in this direction will both improve Türkiye's rankings in global indices and pave the way for the country to achieve its development goals based on a knowledge economy.



ASO-ILTEK 2025 RESULTS AND KEY FINDINGS

“ The index reveals that Ankara and Istanbul are leading cities at the national level in terms of the concentration of technology production and output as well as innovation capacity. ”

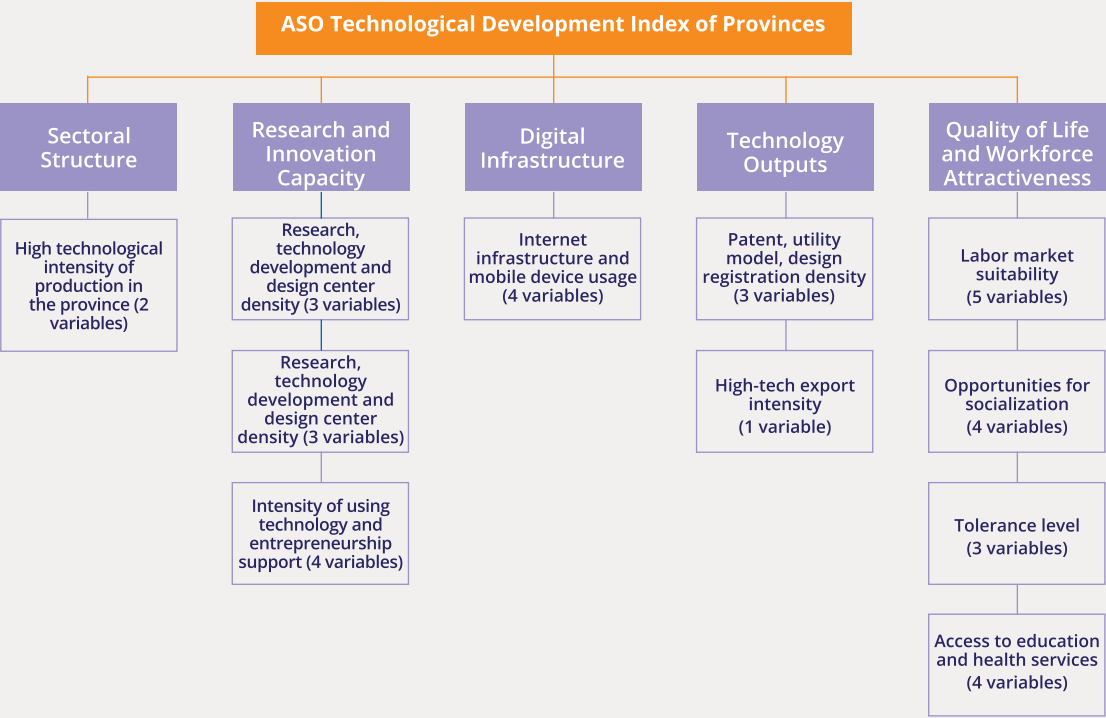
The global economy is progressing in a structure where multi-layered waves of transformation are intertwined. Digitalization, green transformation, accelerating competition in critical technologies and escalating geopolitical tensions have become decisive factors in a wide range of areas, from countries' production structures to firm-level investment decisions. As discussed in Chapter One, global growth is below historical averages; however, scientific publications, R&D spending and progress in critical technologies continue. Nevertheless, this progress is unevenly distributed and fragmented among countries. This picture points to a period in which technological capacity is creating a profound divide not only within the national economy but also between regions and provinces.

Türkiye's position in the global technology system also reflects this transformation. The findings presented in Chapter Two show that Türkiye is one of the middle-income economies that has increased its innovation capacity most rapidly; however, there is still significant progress to be made in areas such as digital infrastructure, data center capacity and high-tech intensive production. Türkiye's rise in global innovation indices (GII 2025, 43rd place) is largely attributed to creative outputs, trade connections, R&D capabilities in defense technologies and momentum in its startup ecosystem. However, the fact that 80.7% of high-tech goods exports in 2024 originated solely from Istanbul and Ankara; that 76% of patent registrations in 2024 were concentrated in five cities (Istanbul, Ankara, Izmir, Bursa and Kayseri); and that Istanbul stood out in the global

ranking of the startup ecosystem, demonstrates that technology inputs and outputs are concentrated in a small number of cities. This concentration on the one hand, points to the asymmetrical distribution of technological within Türkiye and on the other hand, explains why the differences between provinces are widening. This landscape provides a critical framework for how the ASO-İLTEK 2025 results should be interpreted.

ASO-İLTEK has a multi-dimensional structure. The Index structure presented in Figure 3.1 consists of five sub-indices representing the inputs, outputs and facilitators of technology and innovation processes. The sectoral structure sub-index measures the high-technology intensity of the production patterns of the provinces. This variable is considered a facilitating factor in terms of technological development. The research and innovation capacity sub-index consists of variables representing the institutionalized technology infrastructure in the province, academic capacity and the intensity of the use of technology and entrepreneurship support. All these variables are considered as inputs to technology and innovation processes. Similarly, the digital infrastructure sub-index, which is an input-side component of technological development, includes variables representing internet penetration and speed. The quality of life and workforce attractiveness sub-index is the sub-index that covers the broadest set of indicators due to the complexity of the concept it attempts to measure. This sub-index consists of variables representing the suitability of the labor market, opportunities for socialization, creative class attractiveness, tolerance levels and access to education and healthcare services.

Figure 3.1. ASO Structure of the Technological Development Index of Provinces (ASO-İLTEK)



ASO-İLTEK adopts a data-driven, objective and multidimensional statistical approach when measuring the technological development levels of provinces. In the index calculation process, Principal Components Analysis (PCA) method was used to minimize subjective judgments and to consider the natural distribution of the data itself. This method analyzes the correlation structure between variables and mathematically determines the weighting coefficients that best explain the technological performance of the provinces.

The calculation process was carried out in three main steps:

- **Data Standardization:** To make the 37 variables with different units (number of people, dollars, rate, etc.) comparable, a Z-score transformation was applied and then all data were scaled to a range of 0-1 using the Min-Max method.
- **Weighting (PCA):** The contribution of variables and sub-indices to the overall score was determined using the PCA technique, based on their power to explain the variance (variability) of the data, rather than through expert opinion. This ensured that indicators revealing the clearest differences between provinces were given higher weight.
- **Creating the Overall Score:** A final ASO-İLTEK score, ranging from 0 to 1 was generated for each province using a weighted combination of five sub-indices.

The ASO-İLTEK study presents the analysis results in three main outputs: the technological development index scores of the provinces, the ranking based on these scores and a letter grading (level) system that enables the ranking to be converted into a more readable form. The rating method is based on the distribution of the main index scores of the provinces in accordance with the methodological framework adopted in last year's report. Within this framework, the scores of all provinces are first normalized and then, taking into account the structure of the distribution, the provinces are divided into eight categories (AA-FF). For determining categories, classification methods that capture natural critical junctures and cluster tendencies are evaluated together with the equal interval approach; thus, both the statistical integrity and clustering structure of the distribution are preserved. In the final stage, the category results obtained from these three methods are compared to create a consistent rating matrix and each province's final letter grade is determined according to this integrated structure. This method classifies provinces' position in terms of technological development not only based on absolute scores but also by considering the magnitude and distribution of differences between provinces, providing a more understandable and comparable picture for both policymakers and local actors.

The first component of the principal components analysis applied in ASO-İLTEK 2025 explains 63.3% of the total variation, indicating that the model has achieved a stronger representational capacity compared to the previous year (61.4%). This increase indicates both a strengthening of common structural components among sub-indices and a more pronounced divergence in the technology-based transformation of provinces.

The comparison between 2024 and 2025 highlights two dynamics in particular. Firstly, the increase in the weight of digital infrastructure from 0.4034 to 0.4409 (Table 3.1) makes digitalization capacity a more decisive factor in explaining the overall technological performance of provinces. High-speed internet access, fiber infrastructure and connectivity capacity have become key determinants of innovation at the company level, as well as of artificial intelligence applications, data-intensive processes and green transformation technologies, by 2025. In contrast, the weight of the Quality of Life and Workforce Attractiveness sub-index decreased from 0.3175 to 0.2287; this indicates that in 2025, infrastructure and production structure stand out more than quality of life indicators in determining inter-provincial technology differences.

Table 3.1. Weights of Sub-Indices in the First Principal Component

Sub-Index	2023 Weight	2024 Weight	2025 Weight
Research and Innovation Capacity	0,3815	0,5094	0,5245
Sectoral Structure	0,3033	0,4941	0,4973
Technology Outputs	0,3460	0,4826	0,4806
Digital Infrastructure	0,3305	0,4034	0,4409
Quality of Life and Workforce Attractiveness	0,2452	0,3175	0,2287

The second dynamic is the relationship between the disruption experienced in labor-intensive sectors in Türkiye and the technological development levels of the provinces. Indicators for the textile and apparel sector clearly reveal the mechanisms behind this structural transformation: As of September 2025, the Industrial Production Index is 28.2% below the November 2021 level in the textile sector, 28.9% below the June 2023 level in the apparel and clothing sector and 31.6% below the December 2022 level in the leather sector. In the ready-made clothing and textile sector, Türkiye's export share in major markets declined significantly during the 2021-2024 period. This situation is also reflected in registered employment data; the decrease in the total number of compulsorily insured persons under Article 4/a in the textile, clothing and leather sectors exceeded 380,000 people in the three-year period from August 2022 to August 2025. This situation could be considered a structural transformation opportunity for the provinces where these sectors are concentrated; however, the ASO-İLTEK scores of these provinces actually indicate that they lack the necessary competencies for technology investments. Alternatively, a strategy of shifting towards technology-intensive activities in strong sectors is hampered by performance losses experienced by firms operating in those sectors. Therefore, although Türkiye has an opportunity triggered by external conditions to achieve the technological leap it has been aiming for years, the asymmetrical development structure within the country reduces the chances of seizing this opportunity.

“ While the Ankara-Eskişehir and Istanbul-Kocaeli belts maintain their leading positions, the fact that medium and low-tech provinces are stuck in the CC-FF band indicates that technological differences between provinces are deepening due to deficiencies in digital infrastructure and production capacity. ”

Therefore, ASO-İLTEK 2025 is not merely an output showing the technological ranking of provinces. It is also an early warning regional technology map reflecting the spatial dimension of Türkiye's economic transformation, asymmetries in technological development and sector-based vulnerabilities. The mobility of provinces during the 2024-2025 period reveals both the capacity for upward transformation and the downward risks. In this context, the findings of ASO-İLTEK 2025 point to three main trends:

- 1. Polarization is intensifying across technology belts:** While the Ankara-Eskişehir and Istanbul-Kocaeli belts maintain their positions in the upper category, the provinces in the middle group are squeezed into the CC-DD band.
- 2. Risks increase for provinces with low levels of technological development:** The increase in the number of provinces in the FF category to 18 indicates that followers are experiencing convergence problems with leaders. This situation poses risks both for the overall structural transformation of the country and for the adaptation of firms in these provinces to global trends.
- 3. Digital infrastructure and technology outputs have become critical for this leap forward:** The changes in sub-index weights in 2025 show that production capacity and digital connectivity play a decisive role in the technological performance of the provinces.

In this context, the ASO-İLTEK 2025 results are discussed in detail in the following sub-sections of Chapter 3, first at the general index dynamics level then at the technology belt level and finally at the sub-index level. Each sub-index finding, along with its corresponding tables and figures, provides a data-driven explanation of why provinces have risen or fallen; prominent issues such as Kayseri, the Ankara-Istanbul competition, the Izmir-Manisa axis and the quality-of-life performance of Antalya and Muğla are examined in detail in the appropriate sub-sections.

Important Considerations in Data Interpretation

In ASO-İLTEK 2025, the capacity of provinces is analyzed using the most up-to-date official data; certain strategic choices have been adopted stemming from the nature of the data sets, the characteristics of the statistical methods and the thematic focus of the report. When evaluating the findings of the report, it is important to consider the following points in order to place the analysis results in the correct context.

1. Scale Effect: Location of Smaller Provinces

The index methodology uses indicators that are ratioed to population, number of enterprises, or total employment, rather than absolute values, in order to compare Türkiye's metropolitan areas with smaller provinces on a fair basis. This approach can lead to proportionally high scores for a small number of technology or knowledge-intensive service firms in provinces with quantitatively narrow industrial bases, such as Kars and Iğdır. The fact that these provinces rank highly, particularly in the Sectoral Structure sub-index, reflects not a massive production volume but rather the high proportional weight of technology and knowledge-intensive services (telecommunications, software, etc.) within the province's own economic structure. This is not a data bias but a natural consequence of the measurement preference for these densities.

2. Thematic Focus: Defense Industry and Sectoral Transformation Vision

The main theme of the ASO-İLTEK 2025 Report has been determined as defense industry technologies due to its high added value and strategic importance. The strong emphasis placed on this sector in the qualitative analyses of the report does not mean that the challenges faced by traditional sectors such as textiles and ready-made clothing which are a major source of employment in Türkiye are being ignored. On the contrary, the report positions the technological deepening achieved in the defense industry as a leverage for the structural transformation needed by traditional sectors that are losing ground and as a role model to be followed.

3. Structural Advantages and the Effect of Administrative Center

Ankara's leading position in the index results regarding Research and Innovation Capacity and overall score is directly related to the high concentration of public R&D institutions, main defense industry contractors and research universities that come with being the capital city. Rather than excluding this structural advantage as an exception, our methodology incorporates it into the model as a realistic component of a province's technology-producing capacity. The analyses highlight the qualitative difference between Ankara's leadership focused on "production and R&D" and Istanbul's leadership focused on "commercialization and digital infrastructure."

4. Asymmetry Between Potential and Output

The Quality of Life and Workforce Attractiveness component of the index is a potential indicator that measures not the current state of technology production but its future in terms of talent attraction. The fact that provinces like Antalya and Muğla rank at the top

in this sub-index but lag behind in the Technology Output sub-index is not a contradiction but an important observation. This asymmetry represents a "window of opportunity" for policymakers, showing that these provinces have not yet been able to adequately translate their high quality of life advantage into technological production.

5. Data Up-To-Dateness and Time Delay

The data used in this study are the most up-to-date official statistics available from relevant institutions (Turkish Statistical Institute, Turkish Patent and Trademark Office, Ministries, etc.). However, due to the nature of macroeconomic data, some indicators (such as patent registrations and R&D spending) reflect economic activity with a certain lag. Therefore, the index results represent the medium-term structural technological capacity of the provinces rather than instantaneous market fluctuations.

3.1. Overall Index Results

Table 3.2 shows a comparative overview of the provinces' main index scores, rankings and positions in sub-indices as of 2025. This table reveals four key trends regarding Türkiye's technology geography. First, Ankara maintains its leading position, but this year's data indicates a slight narrowing of the gap between Ankara and Istanbul. Ankara still has the strongest ecosystem in the country in terms of R&D-intensive activities, scientific knowledge production and technological outputs but Istanbul's progress in digital infrastructure indicators has narrowed the gap between the two cities. This situation demonstrates that national technological capacity continues to mature along two separate axes and that both competitive and complementary relationships are strengthening between these axes.

“ While Ankara and Istanbul are strengthening their leadership, Kocaeli and Eskişehir, despite their strong technology ecosystems, have made limited progress in research capacity and digital infrastructure, widening the gap between them and the leading duo. ”

Table 3.2. ASO İLTEK 2025 Results

Province	Rating	ASO İLTEK (Score)	ASO İLTEK (Rank)	Rank				
				Sectoral Structure	Research and Innovation Capacity	Digital Infrastructure	Technology Outputs	Quality of Life and Workforce Attractiveness
Ankara	AA	1,000	1	1	1	2	3	11
İstanbul	AA	0,962	2	2	3	1	4	23
Eskişehir	BA	0,675	3	4	4	10	5	16
Kocaeli	BA	0,666	4	3	2	8	8	13
İzmir	BB	0,539	5	5	5	5	9	24
Kayseri	BB	0,526	6	17	6	14	1	56
Bursa	BB	0,525	7	13	8	12	2	48
Sakarya	CB	0,401	8	18	10	36	6	32
Tekirdağ	CC	0,370	9	6	11	32	24	27
Antalya	CC	0,348	10	16	30	7	28	2
Trabzon	CC	0,348	11	20	13	9	25	25
Isparta	CC	0,348	12	23	15	23	10	17
Denizli	CC	0,333	13	22	17	31	12	15
Konya	CC	0,331	14	28	21	42	7	47
Manisa	CC	0,321	15	8	20	60	11	33
Düzce	CC	0,320	16	9	19	55	16	28
Samsun	CC	0,305	17	24	12	21	31	36
Kütahya	CC	0,305	18	47	9	41	21	14
Adana	CC	0,301	19	15	25	6	35	61
Elazığ	CC	0,296	20	26	14	24	18	58
Karabük	CC	0,290	21	37	16	25	19	44
Niğde	CC	0,285	22	43	7	46	20	59
Muğla	CC	0,283	23	42	63	15	39	1
Çanakkale	CC	0,282	24	36	28	34	26	4
Edirne	CC	0,268	25	19	39	22	62	3
Bolu	CC	0,264	26	21	22	49	37	9
Rize	CC	0,263	27	30	26	38	30	21
Bilecik	CC	0,261	28	51	18	29	22	46
Malatya	CC	0,259	29	34	24	11	51	54
Çankırı	CC	0,256	30	49	42	19	17	29
Sivas	CC	0,250	31	14	27	39	46	51

Province	Rating	ASO İLTEK (Score)	ASO İLTEK (Rank)	Rank				
				Sectoral Structure	Research and Innovation Capacity	Digital Infrastructure	Technology Outputs	Quality of Life and Workforce Attractiveness
Adıyaman	DC	0,240	32	63	38	3	34	70
Gaziantep	DC	0,235	33	40	33	26	14	68
Balıkesir	DC	0,226	34	44	50	35	54	8
Kilis	DC	0,223	35	46	69	4	58	66
Kırklareli	DC	0,222	36	10	44	71	52	10
Erzurum	DC	0,220	37	31	23	66	23	34
Aydın	DC	0,219	38	55	36	28	38	31
Karaman	DC	0,211	39	69	34	61	13	37
Nevşehir	DC	0,211	40	57	43	54	33	5
Yalova	DC	0,210	41	27	32	52	41	43
Iğdır	DC	0,210	42	7	46	68	42	60
Mersin	DC	0,208	43	33	37	59	29	40
Kırıkkale	DC	0,207	44	11	35	44	73	62
Burdur	DC	0,206	45	75	53	50	15	20
Aksaray	DD	0,197	46	68	40	13	47	63
Kahramanmaraş	DD	0,196	47	41	29	30	36	74
Amasya	DD	0,192	48	59	72	17	49	41
Artvin	DD	0,187	49	72	78	16	65	12
Uşak	DD	0,187	50	50	60	20	68	45
Zonguldak	DD	0,186	51	48	49	37	53	50
Çorum	DD	0,184	52	45	71	33	40	57
Kastamonu	DD	0,183	53	58	58	58	32	19
Kars	DD	0,180	54	12	67	65	70	35
Afyon	DD	0,174	55	70	45	27	60	52
Ardahan	DD	0,171	56	81	76	18	74	6
Bartın	DD	0,168	57	60	51	45	72	22
Tokat	DD	0,167	58	38	55	69	27	49
Bayburt	DD	0,162	59	52	70	53	44	38
Ordu	DD	0,155	60	64	75	48	43	39
Yozgat	DD	0,153	61	65	54	40	64	55
Hatay	DD	0,146	62	61	47	43	50	71

Table 3.2. ASO İLTEK 2025 Results

Province	Rating	ASO İLTEK (Score)	ASO İLTEK (Rank)	Rank				
				Sectoral Structure	Research and Innovation Capacity	Digital Infrastructure	Technology Outputs	Quality of Life and Workforce Attractiveness
Diyarbakır	DD	0,145	63	25	56	47	67	77
Kırşehir	FF	0,140	64	78	59	56	45	53
Erzincan	FF	0,133	65	53	61	64	76	26
Sinop	FF	0,128	66	77	73	74	61	7
Tunceli	FF	0,125	67	79	57	76	48	18
Giresun	FF	0,123	68	76	66	67	57	30
Van	FF	0,119	69	32	52	57	75	81
Ağrı	FF	0,113	70	39	77	51	80	72
Osmaniye	FF	0,107	71	74	65	62	56	67
Bitlis	FF	0,101	72	67	31	73	77	65
Batman	FF	0,099	73	35	64	75	55	80
Hakkari	FF	0,096	74	29	81	63	81	76
Bingöl	FF	0,091	75	80	48	70	66	64
Gümüşhane	FF	0,084	76	56	62	79	69	42
Siirt	FF	0,071	77	73	68	72	59	73
Şanlıurfa	FF	0,064	78	54	41	78	71	79
Mardin	FF	0,054	79	62	80	77	63	78
Muş	FF	0,026	80	71	74	80	79	69
Şırnak	FF	0,000	81	66	79	81	78	75

“ While Sakarya, Tekirdağ and Karabük are declining in technological capacity, the fact that İzmir, Bursa and Kayseri are catching up to the leading provinces shows that the technological capacity of provinces in the middle-technology belt is susceptible to fluctuations. ”

Thirdly, the tendency of İzmir, Bursa and Kayseri to converge towards the leading provinces is an important finding in the overall structure of the index. These three provinces have demonstrated a move towards leadership by strengthening their performance in sub-indices, particularly through sectoral structure and technological outputs. In 2025, İzmir is projected to maintain stability in digital infrastructure and quality of life indicators while showing only limited improvement in R&D capacity. Bursa has increased its competitiveness through industrial diversification; Kayseri, on the other hand, has attracted attention particularly with its strong performance in technology output. However, the fact that Sakarya, Tekirdağ and Karabük (among the top ten in the ASO-İLTEK 2024 Report) are falling behind in the 2025 results indicates that technological capacity in the mid-segment is both fragile and susceptible to fluctuation. Sakarya and Tekirdağ have not been able to gain sufficient momentum, especially in digital infrastructure indicators; while Karabük has fallen out of the top ten rankings due to its weakness in research capacity and quality of life indicators.

The fourth important finding is that Karabük dropped out of the top ten rankings and Antalya took its place. While Antalya's rise stems from its strong performance in the quality of life and workforce attractiveness sub-indices, the limitations in the province's technological output and research capacity indicate that this rise is not based on a balanced profile. Nevertheless, Antalya's inclusion in the top ten shows that the mobility between the second and third tier provinces can be quite significant in some years.

In 2025, the second noteworthy point is the significant widening of the gap between the axes of Ankara-Istanbul and Kocaeli-Eskişehir which are located in the immediate hinterland of these two provinces. Although Kocaeli and Eskişehir were quite close to the leading group in 2024, they made more limited progress compared to the leading duo, especially in indicators such as research capacity and digital infrastructure and therefore dropped one level in the rating system. In 2024, these two provinces were rated AA, however, both dropped to BA in 2025. This decline indicates that while their technology ecosystems are strong, they are struggling to close the gap with core technology regions. Eskişehir and Kocaeli remain among Türkiye's most innovative provinces but the gap between them and the leaders has widened significantly this year.

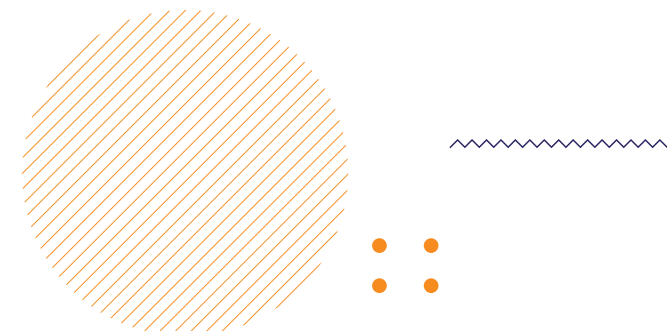


Figure 3.2. Distribution of Provinces' Technological Development Ratings According to ASO-İLTEK Scores (2025)

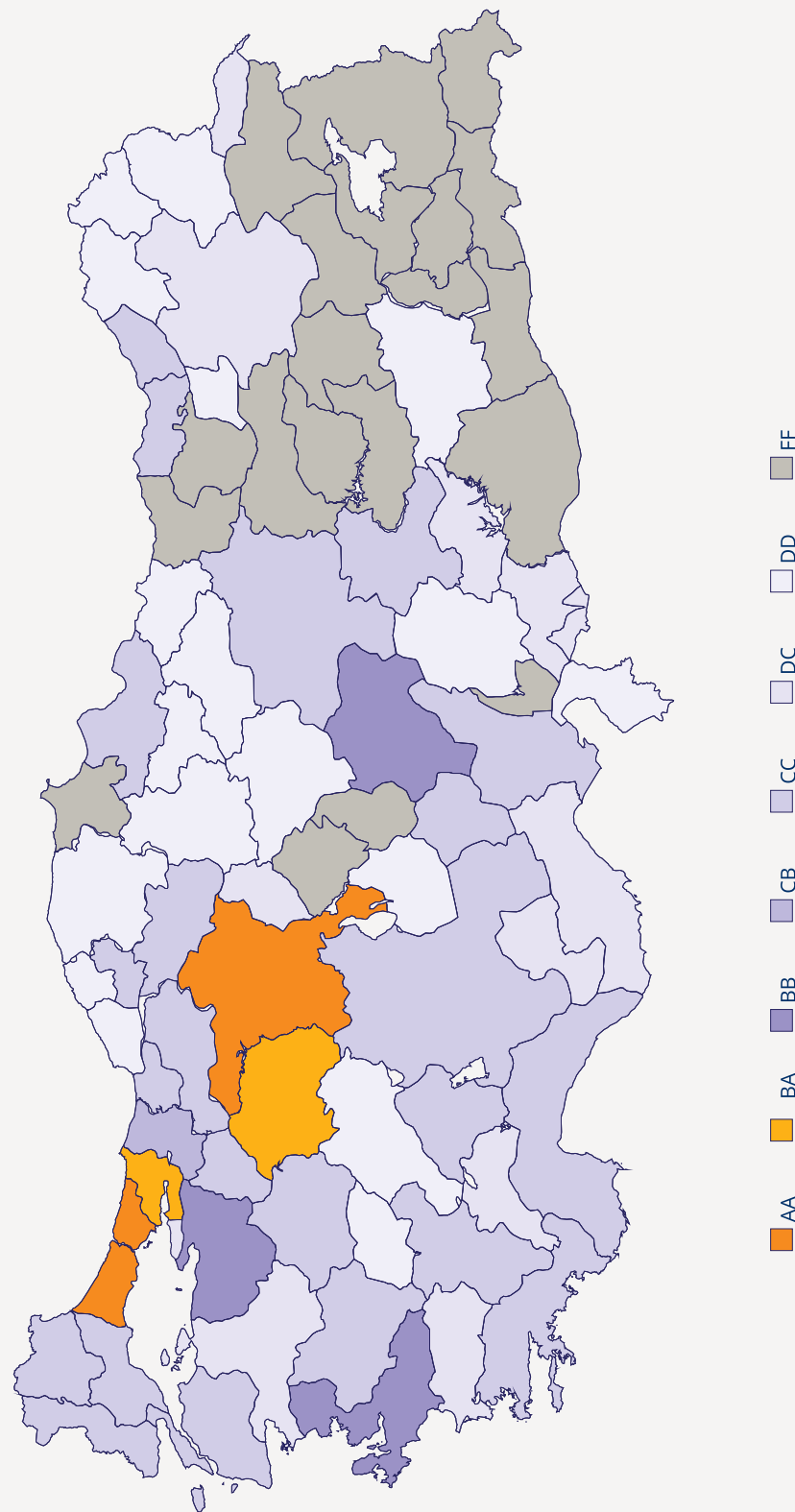


Figure 3.2 presents the spatial distribution of the main index levels of the provinces on a map. This map, like the 2024 results, clearly demonstrates Ankara and Istanbul's dominance in terms of technological capacity nationwide. However, despite the similarity in spatial appearance, Table 3.3 shows that the rating transitions were quite intense this year. The mobility at the upper levels is particularly noteworthy: The fact that Eskişehir and Kocaeli fell to BA in 2025 shows that even high-tech provinces are sensitive to performance differences in the sub-components of the index. Furthermore, the number of provinces with a CB or higher rating decreased from 12 in 2024 to only 8 in 2025. This decline reveals that the gap between leading and following provinces is widening and that upward movement in technological capacity will remain limited in 2025.

Table 3.3. Distribution of Provinces According to the ASO-İLTEK Rating System

Average Score	Rating of Technological Development	Number of Provinces in 2023	Number of Provinces in 2024	Number of Provinces in 2025
[1, 1.5)	AA	2	4	2
[1.5, 2)	BA	2	0	2
[2, 2.5)	BB	2	4	3
[2.5, 3)	CB	3	4	1
[3, 3.5)	CC	19	25	23
[3.5, 4)	DC	18	8	14
[4, 4.5)	DD	15	20	18
[4.5, 5]	FF	20	16	18

The concentration at lower levels further reinforces this picture. The increase in the number of provinces with an FF rating has made the position of the technologically weakest regions more prominent across the country. While examining the degree transition matrix in Table 3.4, it can be seen that 19 of the 24-degree transitions between 2024 and 2025 were downward. This situation shows that a significant number of provinces are struggling to maintain their current positions rather than advance in their technological capacity. Provinces that failed to improve their digital infrastructure and innovation indicators, in particular, tended to fall to a lower rank; thus, the gap between technology leaders and middle and lower-tier provinces has become even more pronounced in 2025.

Table 3.4. Transitions for 2024-2025 According to ASO-ILTEK Ratings

		Iltek 2025 Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
ILTEK 2024 Rating	AA	2	2 ↓						
	BA								
	BB			3	1 ↓				
	CB					4 ↓			
	CC					18	6 ↓	1 ↓	↓
	DC					1 ↑	5	2 ↓	↓
	DD						3 ↑	14	3 ↓
	FF							1 ↑	15

Note: Rank decreases are shown in red, and increases in green. The gray area indicates the number of provinces that have maintained their current classification.

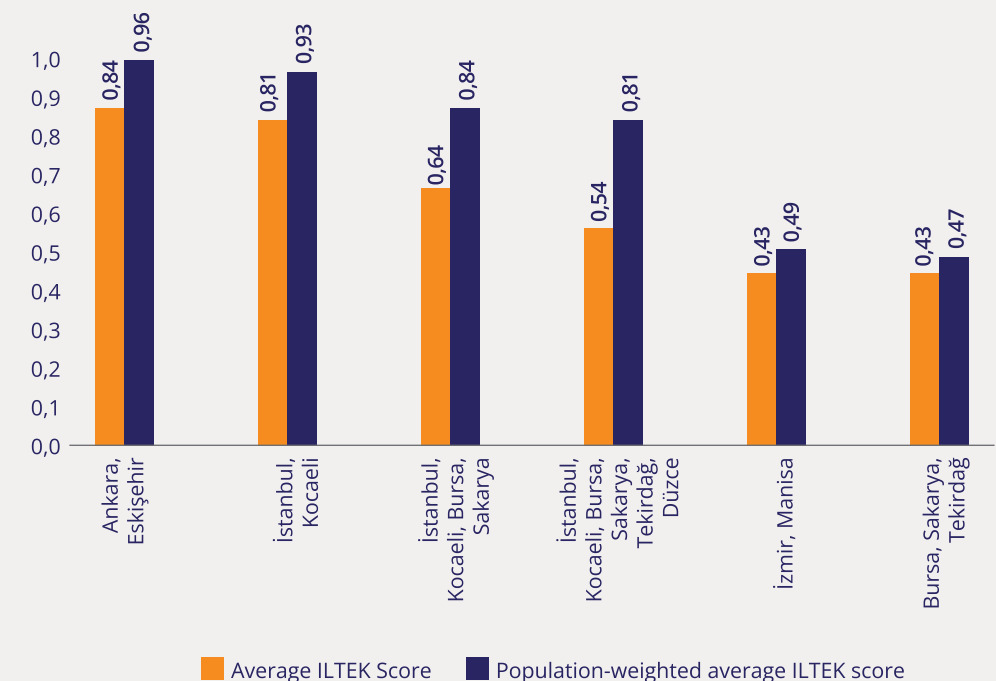
When these findings are considered together, it is seen that Türkiye's technology geography will be consolidated at three main levels by 2025: Ankara-Istanbul, which forms the core technology axis; this is followed by a second group of provinces with strong industry-based technological capacity and a third group of provinces with limited technology indicators. This structure offers important clues not only about the individual performance of the provinces but also about how technological capacity is clustered within the country.

3.2 Technology Belts and Regional Divide

“Türkiye's technology map is shaped around three distinct layers, each with its own characteristics. Innovation and technology capacity, digital infrastructure, R&D and technological outputs play a key role in the differences between these layers.”

One of the most effective ways to analyze structural differences in technology indicators among provinces is to analyze spatial clusters formed by provinces with similar characteristics. In the ASO-İLTEK 2024 Report, the concept of "technology belts," developed for this purpose, defines the Ankara-Eskişehir, İstanbul-Kocaeli and İzmir-Manisa axes as focal points of Türkiye's technological development. While this study adopts the same conceptual framework when evaluating the 2025 results, it takes a more in-depth approach in light of the insights provided by the 2024 and 2025 data. This approach integrates the previous clustering logic with the "triple layer" structure observed over the past two years.

Figure 3.3. Average ASO-ILTEK Scores of Technology Belts (2025)



The ASO-İLTEK 2025 findings show that technological development in Türkiye is concentrated in three fundamental layers that are qualitatively distinct from each other.

- **First Tier:** This is the lead cluster, based in Ankara and İstanbul, forming the core of the national innovation ecosystem.
- **Second Tier:** This is a production-oriented cluster where industry-based technology capacity is dominant, encompassing provinces such as Kocaeli, Eskişehir, İzmir, Bursa, Kayseri and Manisa.

- **The third tier:** This is the broad periphery consisting of provinces that exhibit relatively weak performance in terms of digital infrastructure, R&D capacity and technological output and have a low level of development.

Although this three-tiered classification largely overlaps with the geographical zones in 2024, ASO-İLTEK 2025 data reveals significant repositioning within the internal dynamics of these zones. In particular, the average scores presented for technology belts in Figure 3.3 show that the difference between the first and second technology tiers is quite significant.

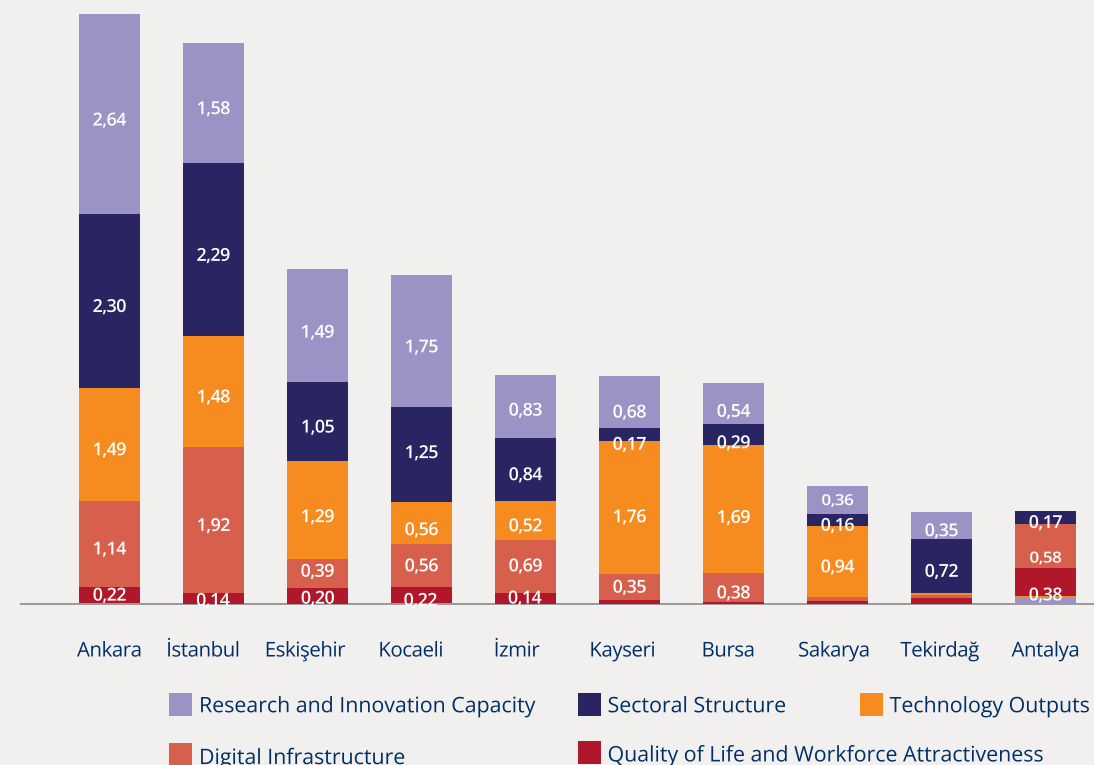
First Tier: Ankara-Istanbul Core

“In Türkiye, technological development is hierarchically divided into a multifaceted upper layer centered around Ankara and Istanbul, a fragile, industry-based second layer and provinces trapped in a low-technology trap.”

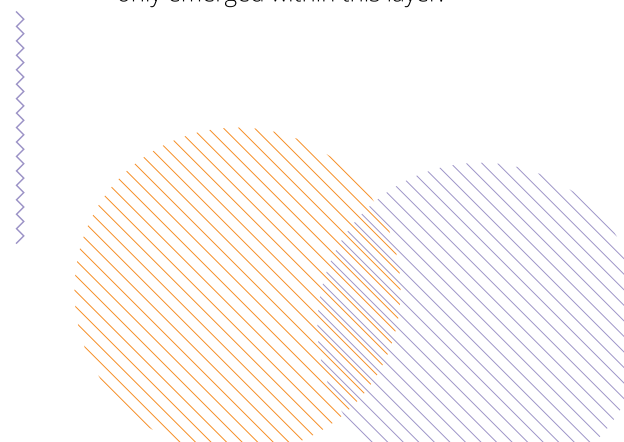


As Figure 3.3 indicates, the first technology layer is taking shape under the undisputed leadership of Ankara and Istanbul. These two metropolises clearly stand out from other provinces in Türkiye's technology ecosystem in terms of both capacity and depth. This core structure which also includes Kocaeli and Eskişehir, demonstrates superiority in critical areas such as high-tech production, qualified R&D infrastructure, established research institutions, effective university-industry collaboration and sectoral diversity.

Figure 3.4. Sub-Index Contributions to the Overall Index of the Ten Provinces with the Highest ASO-İLTEK Results (2025)



The most distinctive feature of this layer is that its technological capacity has a multi-dimensional and holistic structure. Success cannot be reduced solely to R&D intensity or digital infrastructure; there is an organic balance between parameters such as scientific publication production, high-tech exports, entrepreneurial culture and quality of life. As can be seen in Figure 3.4, the overall index scores of the provinces in this group are formed by balanced contributions from all sub-indices not just from a single area. This “balanced contribution profile” shows that truly mature technology zones in Türkiye have only emerged within this layer.



Ankara and Istanbul: Leadership in Different Paths

Ankara and Istanbul are the two main engines of technology in Türkiye, but their operating principles are quite different. According to the data in Figure 3.4, Ankara has established a clear advantage over Istanbul in the sub-indices of Research and Innovation Capacity, Sectoral Structure and Technology Outputs. Indicators such as scientific publication density, number of R&D centers, design registrations and high-tech exports are structural elements that reinforce Ankara's innovation-focused leadership.

The main area where Istanbul has taken the lead is the Digital Infrastructure sub-index. According to 2025 data, the source of this difference is the high density of broadband and mobile internet subscribers as well as the high rate of smart device ownership. Istanbul's high performance in this area becomes even more meaningful when considered alongside TÜİK's classification of urban and rural settlements. According to 2022 data, 11.7% of Ankara's population lives in medium-density urban and rural settlements while in Istanbul this rate is only 3.6%. High levels of urbanization reduce the cost of digital infrastructure while increasing accessibility. Therefore, Istanbul's success in digital infrastructure should be considered a structural advantage stemming from its demographic and settlement patterns.

In conclusion, this table points out two strategic outcomes:

- Ankara is the country's science and technology hub, focusing on innovation, R&D and technology production.
- Istanbul, with its digital infrastructure, service economy and commercialization power, plays the role of a global digital hub that complements this base.

Second Layer: Industry-Based Technology Network

“ Although the Izmir-Manisa axis stands out in the second tier with its strong production capacity, shortcomings in R&D and digital infrastructure are delaying the real leap forward of this potential technology belt. ”

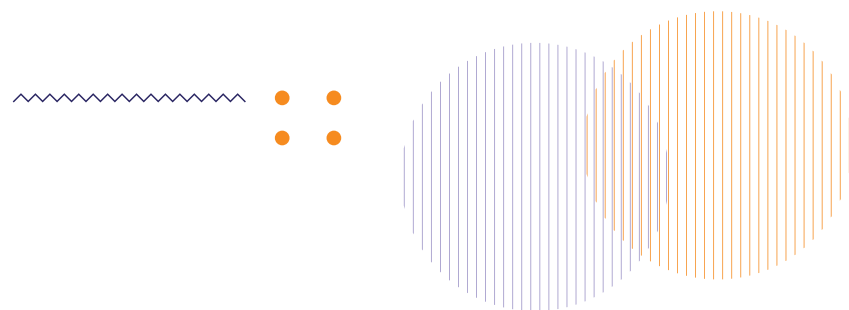
As of 2025, the second layer consists of provinces representing Türkiye's production and industry-based technology capacity. This group, driven by the İzmir-Manisa axis, Bursa and Kayseri, stands out with its heterogeneous and dynamic structure.

The Izmir-Manisa axis strongly retains its potential to become a third technology concentration zone in Türkiye. Although Izmir is approaching the first tier in areas such as digital infrastructure and quality of life, it is not yet at the desired level in terms of R&D and innovation capacity. Manisa stands out with its strong manufacturing industry and medium-high technology production capabilities, but lags behind Izmir in digitalization and R&D indicators. The emergence of these two cities as a technology belt relies on the strength of their production bases; however, reaching the true potential of this belt depends on integrating R&D and digital capabilities into their production capacity.

“ In Kayseri, Bursa and Sakarya, technological performance is directly based on industry-related outputs and limitations in R&D and human capital make it difficult for these provinces to move up to the top league. ”

Other important actors of the second tier; Kayseri, Bursa and Sakarya exhibit a growth model focused on technology outputs. According to the data in Figure 3.4, 60.9% of Kayseri's overall index score, 58.6% of Bursa's and 59.3% of Sakarya's are directly derived from technology outputs. These high rates indicate that the technology profiles of these provinces are largely based on industrial production and export performance but are more limited in other sub-components (R&D, human capital, etc.).

Tekirdağ, however, occupies a unique position within the second tier. The province, which receives 56.4% of its main index score from the Sectoral Structure sub-index, stands out due to the pharmaceutical, electronics and



chemical industry clusters in the Çerkezköy and Çorlu basins (Cansız, Akçomak and Yavan, 2022). Although this sectoral concentration has boosted the province's overall score, it is evident that performance in other technology indicators has not yet fully supported this industrial infrastructure.

Third Layer: Low Technological Threshold and Spatial Vulnerability

“ The increasing number of provinces with FF ratings clearly indicates that technology production is concentrated in a few centers, leaving a wide geographical area below the low technology threshold. ”

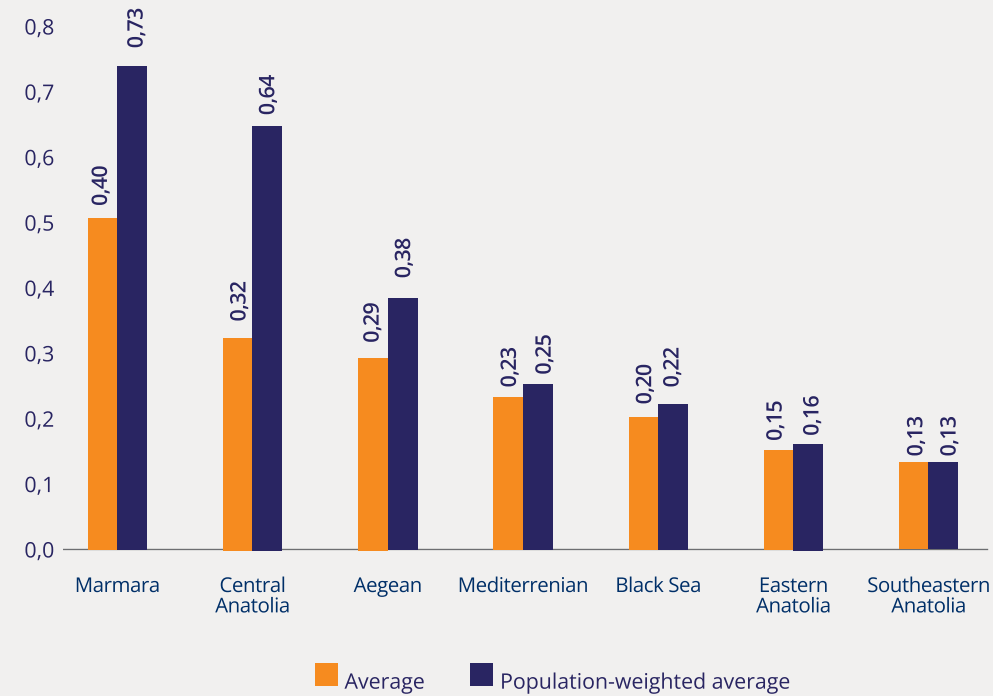
The third layer encompasses a vast geographical area characterized by insufficient R&D investment, limited digital infrastructure and low technological output. The data in Table 3.2 reveals that the average scores of the provinces in this layer show a dramatic decrease compared to the provinces in the first two layers. The increase in the number of provinces with an FF rating (Table 3.3) serves as a warning sign that the low-technology trap is spreading spatially and regional inequality is deepening. This clearly confirms the asymmetrical structure of Türkiye's technology base which is concentrated in the western and northwestern regions.

Belts to Regions: A Reflection of Türkiye's Growth Story

This layered structure in the technology sector is essentially a spatial projection of Türkiye's macroeconomic growth story. The Istanbul-centered growth model adopted in the post-1980 period has caused the Marmara Region to differentiate itself positively from the rest of the country in terms of finance, logistics and industrial networks.

However, in the last decade, developments particularly in the defense, aviation and software sectors have enabled the emergence of a new and powerful technology hub in Central Anatolia. This development along the Ankara-Eskişehir line has transformed Türkiye's technology geography from a Marmara-centric monopoly into a "bipolar" structure centered around Ankara and Istanbul. The regional analysis in Figure 3.5 also confirms this transformation: while the Marmara and Central Anatolia regions are the main carriers of technological capacity, the Aegean and Mediterranean regions are located in the middle tier and Eastern and Southeastern Anatolia are observed as the regions with the lowest technological depth.

Figure 3.5. Average ASO-ILTEK Scores by Geographic Region (2025)



Note: "Average" represents the arithmetic mean of the scores of the provinces in the region; "population-weighted average" represents the average of the provinces' scores weighted by their populations.

Structural Differences Between Leaders and Followers

Figure 3.4 illustrates the qualitative difference between leading and following provinces through the components of their scores. This analysis clarifies two fundamental structural trends:

Balanced and Multidimensional Profile: Leading provinces such as Ankara, Istanbul, Eskişehir, Kocaeli and İzmir generate their overall scores through significant contributions from all sub-indices. Technological development in these provinces is based on an integrated ecosystem where R&D, digitalization, production and quality of life come together.

Dependent and Asymmetric Profile: In other provinces, success is generally dependent on a single sub-index. As previously mentioned, in Kayseri, Bursa and Sakarya, up to 60% of the score is based solely on technology outputs. In Tekirdağ, however, this dependency is in the sectoral structure sub-index.

“Provinces like Antalya, which have a high quality of life but weak R&D and technology production, clearly demonstrate Türkiye’s spatial technology asymmetry.”

Antalya is one of the most striking examples of this asymmetrical structure. While 36.4% of the province's overall index score comes from the Quality of Life and Workforce Attractiveness sub-indices and 55.2% from the Digital Infrastructure sub-indices; the contributions of the Research and Innovation Capacity and Technology Output sub-indices are negative. This picture confirms Antalya's characteristic of having a "high quality of life but weak technology production".

In conclusion, the ASO-İLTEK findings summarize the spatial hierarchy of technological development in Türkiye along three main axes: (1) the multifaceted core layer dominated by Ankara and Istanbul, (2) the second layer held together by industrial and production capacity and (3) the third layer encompassing provinces that have fallen into the low-technology trap.

“The spatial hierarchy of technological development in Türkiye can be summarized as follows: a multifaceted structure dominated by Ankara and Istanbul, a second layer sustained by industrial power and a cluster of provinces trapped in a low-technology environment.”

3.3. Sectoral Structure Sub-Index Results

The Sectoral Structure sub-index is an indicator that measures the technological intensity of the production pattern of the provinces and in this respect, it constitutes the index's one of the most fundamental components. This sub-index shows the extent to which provinces have a technology-based production structure by considering together the weight of high and medium-high technology manufacturing activities, knowledge-intensive services and sectoral diversity within the provincial economy. Thus, it provides information about both the nature of the existing industrial structure and its capacity for technologically aware transformation.

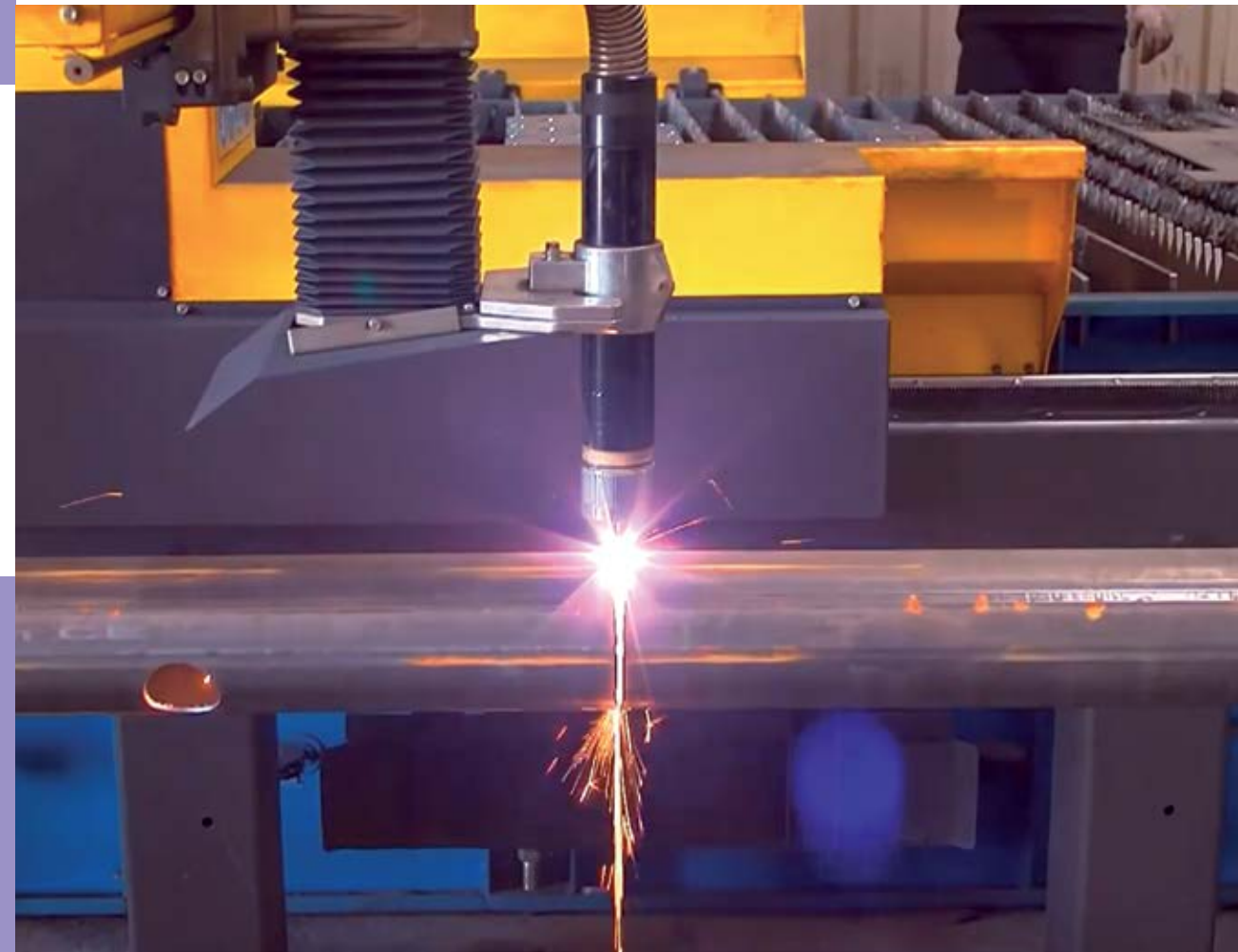
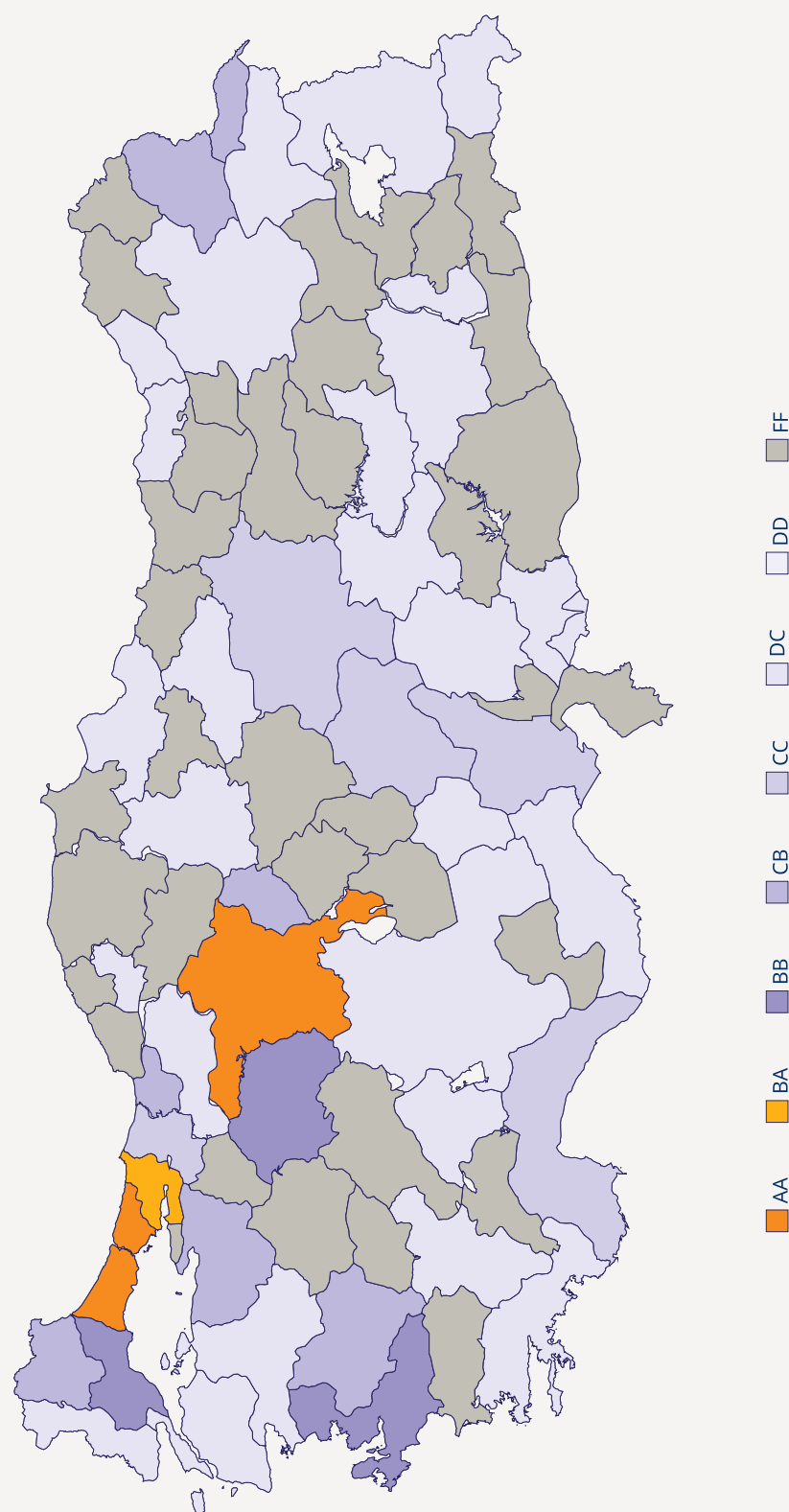


Figure 3.6. ASO-İL TEK Sectoral Structure Sub-Index Levels (2025)



The 2025 results reveal that the differentiation between provinces is quite significant in the Sectoral Structure sub-index. As shown in Table 3.2, Ankara ranks 1st and Istanbul ranks 2nd in this sub-index. The concentration of high-tech manufacturing and knowledge-intensive services in these two provinces places them at the heart of the country's technology-oriented production structure. It is observed that Ankara supports this performance with its defense and aerospace industry, advanced engineering activities and public R&D; while Istanbul supports it with its diversified industrial structure based on electronics, pharmaceuticals, chemicals and information services. Rankings of Kocaeli (3rd), Eskişehir (4th), İzmir (5th) and Tekirdağ (6th) clearly demonstrates the prominence of the industrial corridor between Marmara and Central Anatolia in the Sectoral Structure sub-index.

Figure 3.6 shows the distribution of provinces' ratings (AA-FF) according to the Sectoral Structure sub-index, revealing how concentrated this leadership is in a limited number of provinces. In 2025, only two provinces were able to achieve an AA rating in this sub-index: Ankara and Istanbul. These are followed by Kocaeli, Eskişehir, İzmir and Tekirdağ with a BB rating. All other 75 provinces are classified with a rating of CC or below. This table shows that the high-technology intensive production structure in Türkiye is still confined to a very limited area and the main differences in the production patterns are shaped around a few provinces in the AA-BB range.

“ High-tech manufacturing and knowledge-intensive services are confined to a limited industrial corridor stretching from Ankara and Istanbul, encompassing Kocaeli, Eskişehir, İzmir and Tekirdağ. ”

Although provinces like Bursa and Kayseri are among the top 20 in the Sectoral Structure sub-index, they lag behind the Ankara-Istanbul-Kocaeli-Eskişehir-Izmir-Tekirdağ line. Bursa's sectoral structure ranking is 13th, while Kayseri's is 17th (Table 3.2). This situation shows that both provinces have a strong industrial base but they have not been able to deepen their presence in high-tech manufacturing and knowledge-intensive production activities as much as the leading provinces. Kayseri ranks in the middle-to-upper range in the Sectoral Structure sub-index while it holds a very high position in the Technology Outputs sub-index. This situation shows that while the province's current industrial structure is effectively linked to innovation activities, the sectoral composition still remains predominantly at the medium-technology level. Therefore, as will be discussed in detail in section 3.6, Kayseri can be considered a strong but not a leading member of the second tier in terms of sector structure, primarily distinguished by its technological outputs.

Tekirdağ's position in the Sectoral Structure sub-index is a striking example demonstrating the relationship between this sub-index and industrial clusters.

Tekirdağ ranks 6th in the sectoral structure ranking and owing to the electronics, pharmaceutical and chemical industries concentrated especially around Çerkezköy and Çorlu, it brings the share of high-tech manufacturing in total manufacturing to a relatively high level (Cansız, Akçomak and Yavan, 2022). Large-scale investments in the Organized Industrial Zones located in the province strengthen Tekirdağ's sectoral composition, while more limited performance in other sub-indices (e.g., research capacity and technology outputs) indicates that this structure is not reflected equally across the entire technology ecosystem. Nevertheless, in terms of the Sectoral Structure sub-index, Tekirdağ stands out as an important industrial region located in the continuation of the Istanbul-Kocaeli belt.

Provinces such as Sakarya and Karabük have shown a relative downward trend in terms of sectoral structure in 2025. While Sakarya was among the top ten in 2024, it could not maintain this position in 2025 both in the main index and in the sectoral structure sub-index. Fluctuations, particularly in the automotive and related industries, have limited the share of high-tech manufacturing in the total which has been reflected in the province's sectoral performance. In Karabük, the inability to sufficiently diversify the heavy metal-based industrial structure with high-technology production methods has caused the province to drop out of the top ten in the overall index and to experience a relative weakening in terms of sectoral structure. These two examples demonstrate that having a strong industrial base alone is not sufficient for high Sectoral Structure performance; diversification of the industrial structure towards technology-intensive areas is critically important.

On the other hand, a striking divergence from the general geographical pattern and industrial concentrations is observed specifically in Kars and Iğdır within the Sectoral Structure sub-index (Figure 3.6). The main reason for this positive divergence from other provinces in the Eastern Anatolia Region is the proportionally high share of those employed in high-tech manufacturing and knowledge-intensive service activities within the pool of compulsory insured persons under Article 4-1/a. However, when the manufacturing-services distribution is analyzed in detail, it becomes clear that this success stemmed entirely from the services sector rather than an industrial breakthrough.

An analysis of the data reveals that in Kars employment in the high-tech manufacturing industry (4-1/a category) is only 3 people; however, employment in knowledge-intensive services (sectors coded NACE 59, 60, 61, 62, 63 and 72) reaches 758 people. In due reason of this service-intensive sector, its share of the total employment in the province is calculated as 2.9%. As a striking comparison, this rate is 0.81% in industrial giant Bursa and 2% in Izmir. A similar arithmetic effect applies to Iğdır where high-tech manufacturing employment remains limited to 3 people while employment in knowledge-intensive service sectors totaling 626 people, brings this sector's share of total 4-1/a employment to 3.1%. These findings reveal that the Sectoral Structure scores of Kars and Iğdır stem not from a production-based technological transformation but rather from the relatively low weight of information-intensive services such as telecommunications and information technology within total employment. This situation is also considered to be related to the causes and processes described in academic literature as the "border effect".

Table 3.5. Transitions between 2024-2025 According to ASO-İLTEK Sectoral Structure Sub-Index

		2025 Sectoral Structure Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
2024 Sectoral Structure Rating	AA	2							
	BA								
	BB		1 ↑	3					
	CB								
	CC				5 ↑	5	4 ↓		
	DC						1 ↑		
	DD				2		22 ↑		2 ↓
	FF						1		33

Note: Rank decreases are shown in red, and increases in green. The gray area shows the number of provinces that have maintained their rank.

The degree transitions related to the Sectoral Structure sub-index are summarized in Table 3.5. It is observed that this sub-index also experienced upward and downward movements during the 2024-2025 period. Two cities with an AA rating (Ankara and Istanbul) have maintained their status; one of the cities in the BB category moved to BA, while the ratings of three remained the same. The biggest change occurred in the provinces that received a CC rating in the 2024 report. Four of these provinces dropped down rating, five increased and five maintained. Of the 37 rating transitions that have occurred, 31 were upward but as of 2025, 28 are rated DC and 35 are rated FF. These transitions also show that in terms of sectoral structure, provinces have not actually achieved a significant upward leap and some provinces have even experienced a regression in their technology-intensive production structure.

Overall, the 2025 Sectoral Structure sub-index findings reveal that Türkiye's level of technological advancement is strongly influenced by its industrial composition and that the production pattern is concentrated along the Ankara - Istanbul - Kocaeli - Eskişehir - İzmir - Tekirdağ axis. However, the fact that the industrial structure in many provinces is still based on low and medium technology sectors has led to CC and lower grades dominating the Sectoral Structure sub-index. This situation, on the one hand, strengthens high-tech clusters and on the other hand, it brings with it the risk of provinces outside these clusters falling behind in the technology race. This emerging picture in the sectoral structure becomes clearer when evaluated together with the differences observed in the research and innovation capacity, digital infrastructure and technology output sub-indices in the following sub-sections reveal the aspects in which the technology profiles of the provinces differ.

3.4. Research and Innovation Capacity Sub-Index Results

“ Ankara's significant advantage in research and innovation capacity reinforces its central position in Türkiye's science and technology production. ”

The Research and Innovation Capacity sub-index is one of the most critical components of the ASO-İLTEK study. This sub-index measures the capacity of provinces to generate scientific knowledge, conduct R&D activities, support technology development processes and produce innovative outputs. Research performance of universities, the density of R&D centers and design units, the effectiveness of technology development zones, the number of research projects and their impact on industry constitute the basic components of this sub-index. The quality of human capital, the depth of research infrastructure and the innovation tendencies of firms are the main factors determining the differences between provinces.

The importance of this sub-index is clearly seen in the principal components analysis. The fact that the Research and Innovation Capacity sub-index has a higher weight in the first component explaining the main index compared to other sub-indices shows that innovation capacity is the dimension that best distinguishes technological development in Türkiye. Therefore, performance in this sub-index plays a decisive role in determining the overall technology scores of the provinces.

As shown in Table 3.2, Ankara is the strongest city in Türkiye in the Research and Innovation Capacity sub-index. With the combined effect of its research universities, defense and aerospace industry clusters, public R&D institutions and technopark ecosystem, the capital is the main center for the production of scientific and technological knowledge within the country. Indicators such as the number of scientific publications, R&D spending and researcher density clearly show that Ankara has a significant advantage.



TÜBİTAK MAM / Kocaeli

“ The key factors that make Kocaeli stand out significantly in terms of R&D capacity are: TÜBİTAK MAM, the Informatics Valley and its strong industrial infrastructure. ”

In this sub-index, Ankara is followed by Kocaeli. Kocaeli's second-place ranking in this sub-index demonstrates that combined with research and innovation, the province's industry-based structure generates strong capacity. TÜBİTAK Marmara Research Center, the Informatics Valley and the innovation activities of the industry are fundamental elements supporting Kocaeli's research infrastructure. Istanbul ranks third; its extensive university network, private sector R&D investments and technopark ecosystem keep its innovation capacity high. These three provinces form the scientific base of the core region in Türkiye where R&D and innovation activities are spatially concentrated.

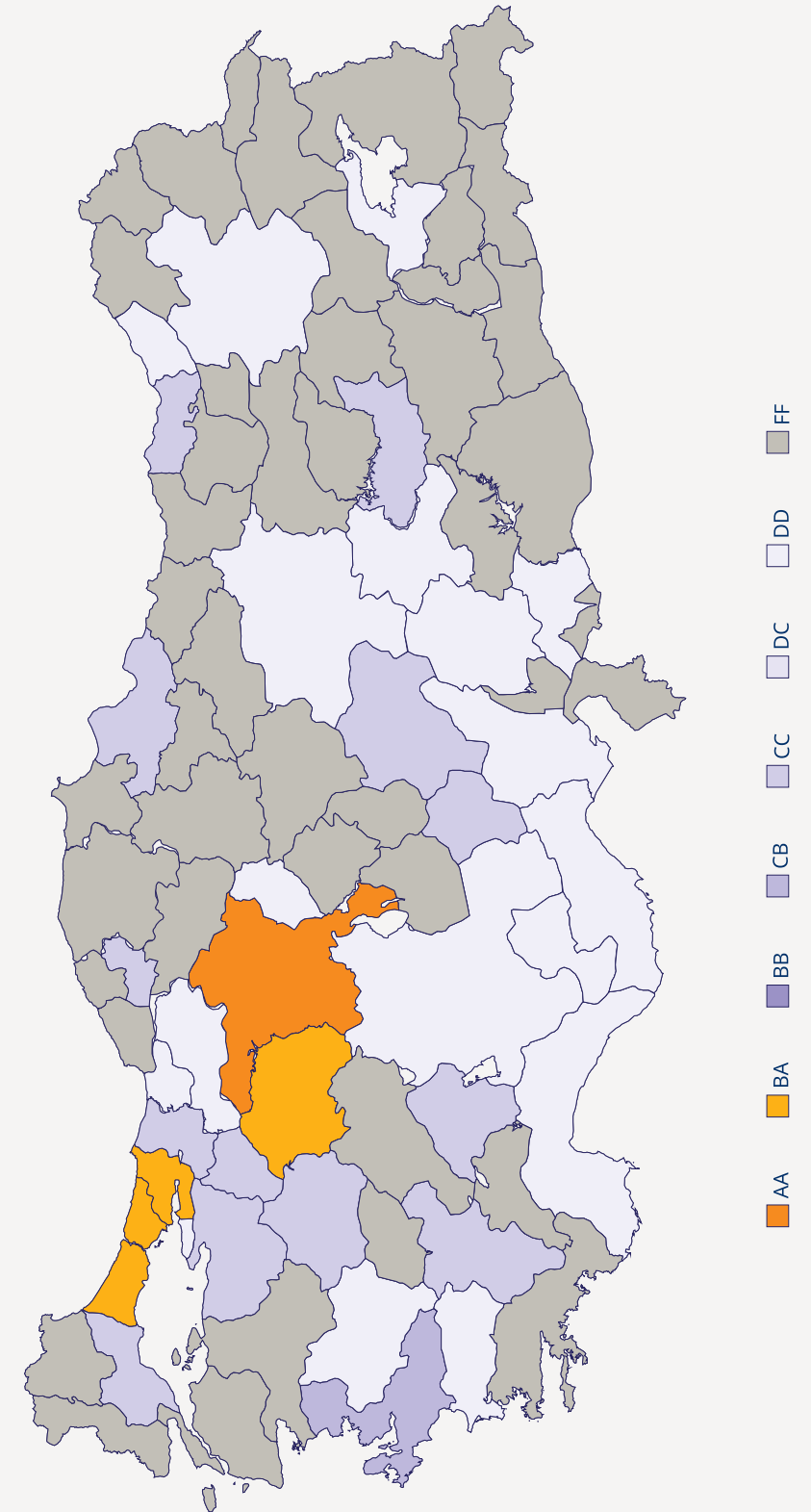


TF33 Engine DSB Project - TAI / Eskişehir

“Eskişehir stands out as a complementary center with its specialized engineering fields, İzmir with its academic and research infrastructure and Bursa with its industry-based innovation.”

This structure is followed by provinces such as Eskişehir, İzmir and Bursa. Eskişehir's expertise and research infrastructure, particularly in specialized fields like aviation and rail systems, strengthens university-industry interaction in the city. İzmir ranks highly in the Research and Innovation Capacity sub-index due to the diversity of its research universities, its scientific publication performance and its R&D projects. In Bursa, innovation activities in sectors such as automotive and machinery, combined with the city's engineering expertise, create significant innovation potential. These provinces represent the second strongest link in terms of research capacity, following the Ankara-Kocaeli-Istanbul trio.

Figure 3.7. ASO-ILTEK Research and Innovation Capacity Sub-Index Levels (2025)



In terms of research and innovation capacity, Kayseri, Tekirdağ, Konya and some other Anatolian cities stand out among the provinces in the upper-middle segment. In these provinces, R&D activities are concentrated around specific sectors; however, the overall research ecosystem has not yet reached the diversity and depth seen in the leading provinces. Therefore, these provinces are progressing by specializing in specific areas while developing their innovation capacity; as universities strengthen their collaborations with industry, they have the potential to improve their position in the sub-index.

The table offers a more limited view for the provinces in the lower segment. In provinces where research infrastructure is weak, university capacity is limited and access to R&D support is low, DD and FF grades are concentrated in the Research and Innovation Capacity sub-index. The ranking distribution in Figure 3.7 shows that strong performance in this sub-index is concentrated in a few centers while numerous provinces rank low in terms of research capacity. The low number of research units, low scientific publication density and limited use of R&D and entrepreneurship support in these provinces hinder the upward movement of overall technological capacity.

Table 3.6. Transitions between 2024-2025 According to ASO-İLTEK Research and Innovation Capacity Sub-Index

		2025 Research and Innovation Capacity Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
2024 Research and Innovation Capacity Rating	AA	1	1 ↓						
	BA		1						
	BB		1 ↑			1 ↓			
	CB					1 ↓			
	CC				1 ↑	9		1 ↓	
	DC					1 ↑		3 ↓	
	DD					1 ↑		10	9 ↓
	FF							5 ↑	35

Note: Rank decreases are shown in red, and increases in green. The gray area shows the number of provinces that have maintained their rank.

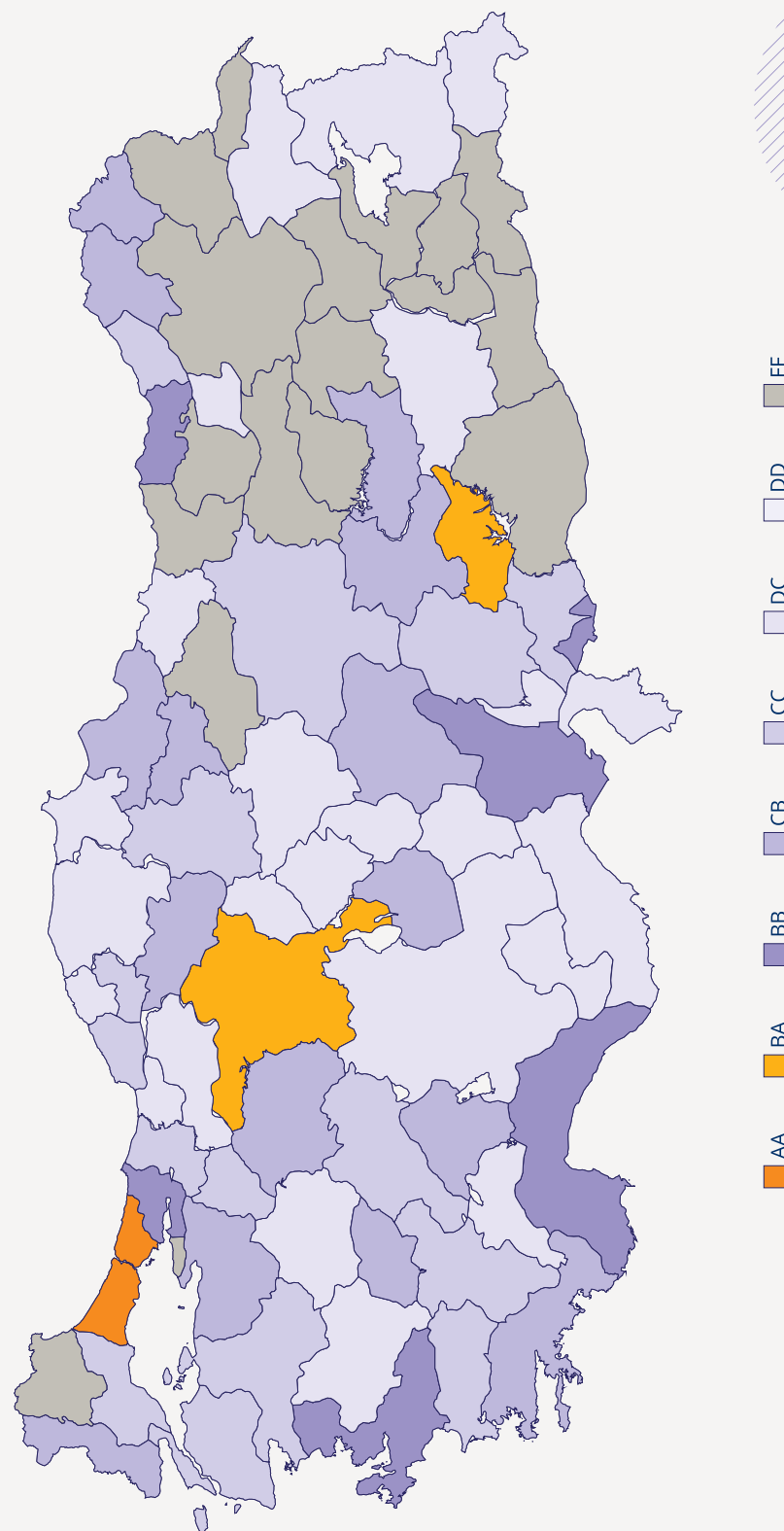
Between 2024 and 2025, a limited number of upward and downward shifts were observed in the Research and Innovation Capacity sub-index. Table 3.6 shows that some provinces moved up a level while others regressed; however, the overall picture indicates that structural differences in this sub-index do not easily change in the short term. It is noteworthy that while the rankings of 56 provinces in this sub-index remained constant during the 2024-2025 period, 16 of the 25 ranking shifts were downward. Since establishing research infrastructure, training human resources and institutionalizing university-industry collaboration are long-term processes, it is not realistic to expect sudden leaps in this field. Nevertheless, it is observed that some provinces, particularly those in the upper-middle segment have improved their rankings while downward trends are more pronounced in the lower segment. This situation indicates that provinces with strong initial conditions have maintained their advantage while those with weak research infrastructure have struggled to move upwards.

Findings from the Research and Innovation Capacity sub-index play a central role in interpreting the overall index results. The fact that the leading provinces are clearly ahead in overall technology scores is largely due to their superior performance in this sub-index. Similarly, the inability of middle and lower-ranking provinces to close the gap with the leaders clearly highlights the importance of policies aimed at deepening the R&D ecosystem and strengthening innovation capacity. Therefore, Research and Innovation Capacity should be considered not only as a sub-index explaining current differences but also as one of the key areas that will determine how technological differences between provinces will evolve in the future.

3.5.Digital Infrastructure Sub-Index Results

The Digital Infrastructure sub-index is one of the directly measurable components among the five components evaluating the digital transformation capacity of provinces. This sub-index which measures the digitalization infrastructure of provinces through indicators such as broadband access, fiber infrastructure penetration, mobile broadband usage rate and mobile phone ownership has increased its weight in 2025 and has become one of the areas that clearly explains the differences in development between provinces.

Figure 3.8. ASO-İLTEK Digital Infrastructure Sub-Index Rankings (2025)



According to the 2025 ranking, the provinces that are among the top 10 in digital infrastructure and have a rating of BB or higher are: Istanbul, Ankara, Adiyaman, Kilis, Izmir, Adana, Antalya, Kocaeli, Trabzon and Eskisehir. First on the list, Istanbul has a significant advantage over other provinces in terms of broadband subscriptions, mobile data usage and phone ownership. Dense urban settlement, the size of the user base and the ability of service providers to benefit from economies of scale differentiate Istanbul from other cities in the field of digital infrastructure. Ankara ranks second in the digital infrastructure index. However, Istanbul's advantage over Ankara stems particularly from indicators such as mobile broadband subscriber density and mobile phone ownership. On the other hand, the proportion of broadband subscribers with fiber optic connections is higher in Ankara than in Istanbul. The Digital Infrastructure sub-index contributed 14.7% to Ankara's overall index score, while the same rate was 25.9% in Istanbul.

“ Istanbul's leadership in digital infrastructure is based more on a structural advantage stemming from urbanization density and economies of scale than on technology policy. ”

The most striking result of this sub-index is that Adiyaman and Kilis will continue to rank highly in digital infrastructure in 2025. Adiyaman is in third place and Kilis is in fourth. While this view may seem surprising at first glance, it is consistent with two key explanations discussed in detail in the 2024 report. Firstly, the presence of the Syrian population creates an increase in the level of digital infrastructure indicators but since these indicators are scaled relative to the provincial population a potential bias arises. Secondly, the high digital infrastructure indicators in border provinces are explained by a potential bias, referred to in academic literature as the "border effect" which is sometimes related to border trade, foreign entrepreneurial activity and communication flows associated with smuggling. These two mechanisms constitute the main reasons why Adiyaman and Kilis have performed better than expected in digital infrastructure. On the other hand, the ASO-İLTEK 2025 results also point to a remarkable shift in these two provinces: while Istanbul, Ankara, Adiyaman and Kilis were in the top category with an AA rating in digital infrastructure in 2024, only Istanbul managed to maintain its AA rating in 2025. Ankara and Adiyaman have dropped to BA rating, while Kilis has dropped to BB rating. There are two possible factors behind this decline. Firstly, the decrease in the Syrian population in Türkiye after 2023 may have caused a drop in absolute and per capita usage rates, especially in mobile communication intensity indicators.

Secondly, the earthquake of February 6, 2023, affected both infrastructure usage behavior and the spatial distribution of data flow resulting in a temporary or structural decline in digital infrastructure indicators, particularly in provinces like Adiyaman. When these two effects are considered together, it becomes understandable why the very high performance seen in 2024 would decline to a more "normalized" level in 2025.

Table 3.7. Transitions between 2024-2025 According to ASO-İLTEK Digital Infrastructure Sub-Index

		2025 Digital Infrastructure Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
2024 Digital Infrastructure Rating	AA	1	2 ↓	1 ↓					
	BA								
	BB			5	9 ↓	1 ↓	1 ↓		
	CB					2 ↑			
	CC				6	11 ↑	6		
	DC					1	11 ↑		↓
	DD						5 ↑		
	FF						1		10

Note: Rank decreases are shown in red, and increases in green. The gray area shows the number of provinces that have maintained their rank.

The top 10 provinces by rank include Istanbul, Ankara, Adiyaman and Kilis followed by Izmir, Adana, Antalya, Kocaeli, Trabzon and Eskisehir. Izmir's strong performance is related to the ease of access offered by its urban structure, but it is also noteworthy that the province's fiber optic network density is relatively low. Adana's performance in the field of digital infrastructure is determined by its high mobile phone ownership and mobile broadband subscription density. Ranking among the top seven provinces in these two provinces, Adana is ranked 33rd and 39th respectively in broadband subscriber density and fiber subscription. In Antalya, factors such as high service sector concentration, tourism-related demand and foreign population stand out as drivers of the digital infrastructure performance. Kocaeli maintains a stable position in digital infrastructure due to its large-scale organized industrial zones and high volume of corporate data usage. Trabzon's ranking among the top ten cities in fiber optic connectivity boosts its digital infrastructure indicators while Eskişehir's user base linked to universities and service sectors supports its position in this sub-index.

One of the most important findings of the digital infrastructure sub-index is the high degree of mobility experienced during the 2024-2025 period. As shown in Table 3.7,

the rankings of 43 provinces have changed with 30 of these changes being downward. This situation shows that digital infrastructure is one of the sub-indices where inter-provincial disparities has widened most rapidly in 2025. The intensity of these downward movements indicates that digital infrastructure indicators are sensitive to demand elasticity and changes in macroeconomic conditions. However, the intensity reveals that the combined trend of economic slowdown, household usage preferences, regional demographic movements and service provider investments can affect this sub-index in the short term.



“ Digital infrastructure has accelerated national technological transformation and has become a key determinant of regional transformation. ”

When these findings are evaluated together, the Digital Infrastructure sub-index presents a picture in Türkiye's technology geography where leading provinces are strengthening and provinces in the middle and lower bands are declining. While major centers like Istanbul and Ankara maintain high levels of digitalization, digital infrastructure indicators in most provinces are projected to weaken by 2025, widening the gap between provinces. This picture shows that in Türkiye, digital infrastructure is no longer just a complementary element; it has become the main determinant of technology-based transformation. It is clear that middle and lower-segment provinces need policy tools to address the disparities particularly in fiber access, broadband subscriptions and mobile coverage.

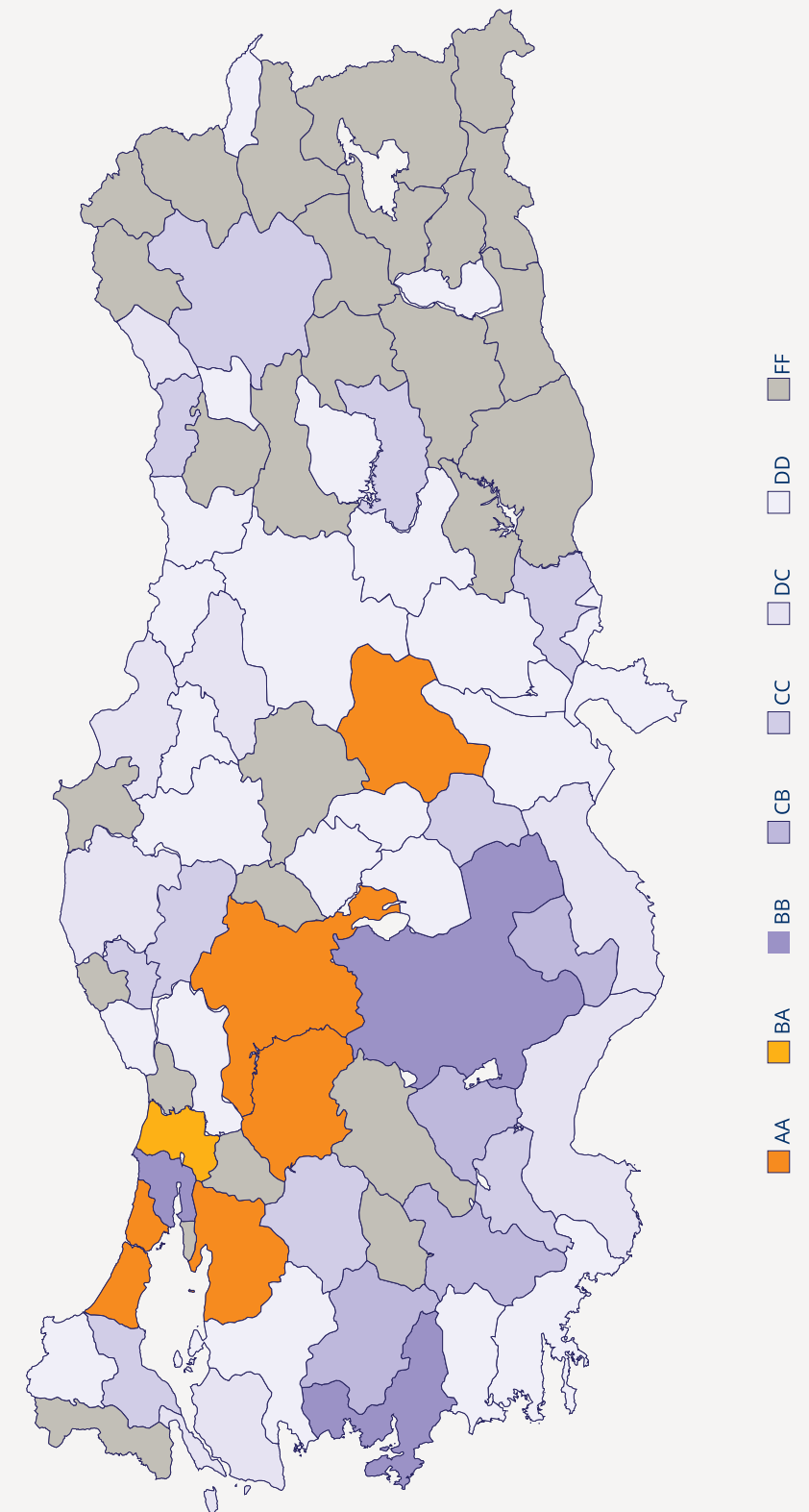
3.6. Technology Outputs Sub-Index Results

“ Kayseri's rise to the top in technological output demonstrates that innovative production is spreading to a broader industrial base. ”



The Technology Outputs sub-index is one of the most dynamic components, as it measures the final stage where the innovative capacity of provinces is transformed into economic output. It is a combined assessment of indicators such as patent, utility model, design and trademark registrations and high-tech exports, reflecting not only a province's ability to produce technology but also its capacity to commercialize, protect and market that production. Therefore, changes in technological outputs are considered one of the strongest indicators of the technology-based growth potential of provinces.

Figure 3.9. ASO-ILTEK Technology Output Sub-Index Rankings (2025)



The success of Kayseri and Bursa in technological output is primarily due to their high density of design registrations. The fact that the number of design registrations per company in Kayseri is 1.98 times higher than in Istanbul and 3.07 times higher than in Ankara demonstrates the exceptionally high innovative design capacity of the province relative to its scale. Bursa has similarly demonstrated a strong performance in this area. The fact that in 2024, Kayseri and Bursa together accounted for approximately one-fifth (19.4%) of all design registrations in Türkiye shows the significant weight of these provinces in design-oriented innovation. This high concentration of design registrations is one of the key factors supporting the competitiveness of both provinces in terms of technological output.

“ Kayseri and Bursa created a strong leap in innovation by leading the number of designs, patents and utility models but they lag behind Ankara and Istanbul in high-tech exports. ”

However, the success of Kayseri and Bursa is not limited solely to design registrations. The number of patent registrations per company in Kayseri is 79.5% of Ankara's and 95.3% of Istanbul's. This data shows that Kayseri performs similarly to the two metropolitan provinces in terms of both diversity and depth of patent production; it indicates that innovative activity in the province can be taken beyond design stages. A similar picture emerges in utility model registrations as well. The number of utility model registrations per company in Bursa is 1.61 times higher than in Ankara and 1.49 times higher than in Istanbul. The fact that this indicator is also higher in Kayseri confirms that the city has a very strong capacity to produce practical and commercially viable inventions.

The key factor preventing Ankara and Istanbul from declining in this sub-index is the high-technology export variable. Although Bursa and Kayseri demonstrate strong performance in registration indicators, their high-tech export values per manufacturing enterprise are only 3-4% of Ankara's level. This indicates that the two metropolitan provinces still have a high level of integration into global value chains; however, Kayseri and Bursa rely more on the domestic market and the medium-high technology product group in technology commercialization. Therefore, the ranking in the technology output sub-index reflects the difference between the innovation production capacity of the provinces and the potential of these innovations to create value in foreign markets.

Table 3.8. Transitions from 2024-2025 by ASO-ILTEK Technology Output Sub-Index

		2025 Technology Outputs Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
2024 Technology Outputs Rating	AA	5							
	BA								
	BB		1 ↑ 3		1 ↓				
	CB								
	CC				3 ↑ 5		2 ↓ 2	1 ↓ 1	1 ↓ 1
	DC					4 ↑ 4		3 ↓ 3	1 ↓ 1
	DD					3 ↑ 3	1 ↑ 1	9	1 ↓ 1
	FF							12 ↑ 20	

Note: Rank decreases are shown in red, and increases in green. The gray area shows the number of provinces that have maintained their rank.

The rating dynamics of the technology output sub-index in the 2024-2025 period are also noteworthy. During this period, the ratings of 35 provinces changed; of these, 24 were upward movements and 11 were downward movements. The dominance of upward trends indicates that the technology output components are more responsive than the components of the Sectoral Structure and Digital Infrastructure sub-indices. However, as of 2025, 68 provinces still have a Technology Output sub-index rating of CC or below (Table 3.8). This table shows that innovative activity in Türkiye is still concentrated in certain provinces; that the technology commercialization capacity is regionally limited and there is significant room for improvement in this area.

Overall, the Technology Output sub-index is one of the most dynamic components in Türkiye's technology ecosystem. Kayseri's leap forward, Bursa's stable performance, Ankara and Istanbul's commercialization capabilities and Eskişehir's contribution based on sectoral specialization clearly demonstrate the diversity in the technology profiles of the provinces. However, many provinces still produce low levels of technological output which means Türkiye's innovative capacity is concentrated in a geographically limited area; strongly indicating the need to expand technology commercialization processes.

3.7. Quality of Life and Workforce Attractiveness Sub-Index Results

The Quality of Life and Workforce Attractiveness sub-index is a critical dimension for the sustainability of the technology ecosystem, measuring the capacity of provinces to attract and retain skilled labor and the creative class. This sub-index brings together elements such as cost of living and wage levels, cultural and social life indicators, health and education infrastructure, urban living conditions, tolerance levels, labor market indicators and demographic mobility. Understanding how qualified human resources are distributed among provinces and which provinces stand out in attracting creative talent offers important clues for understanding long-term trends in Türkiye's technology landscape.

The 2025 results show that the weight of this sub-index within the overall index has decreased compared to previous years. As can be seen in the principal component weights in Table 3.1, the decrease in the sub-index weight compared to 2024 indicates that innovation capacity and digital infrastructure have become more dominant among the main factors determining technological development. Nevertheless, this sub-index continues to be one of the key factors determining the spatial distribution of skilled labor.

“ A high quality of life, combined with R&D and production infrastructure, transforms into a true technology ecosystem; Ankara and Kocaeli are the provinces that achieve this balance. ”

Figure 3.10. ASO-ILTEK Quality of Life and Workforce Attractiveness Sub-Index Rankings (2025)

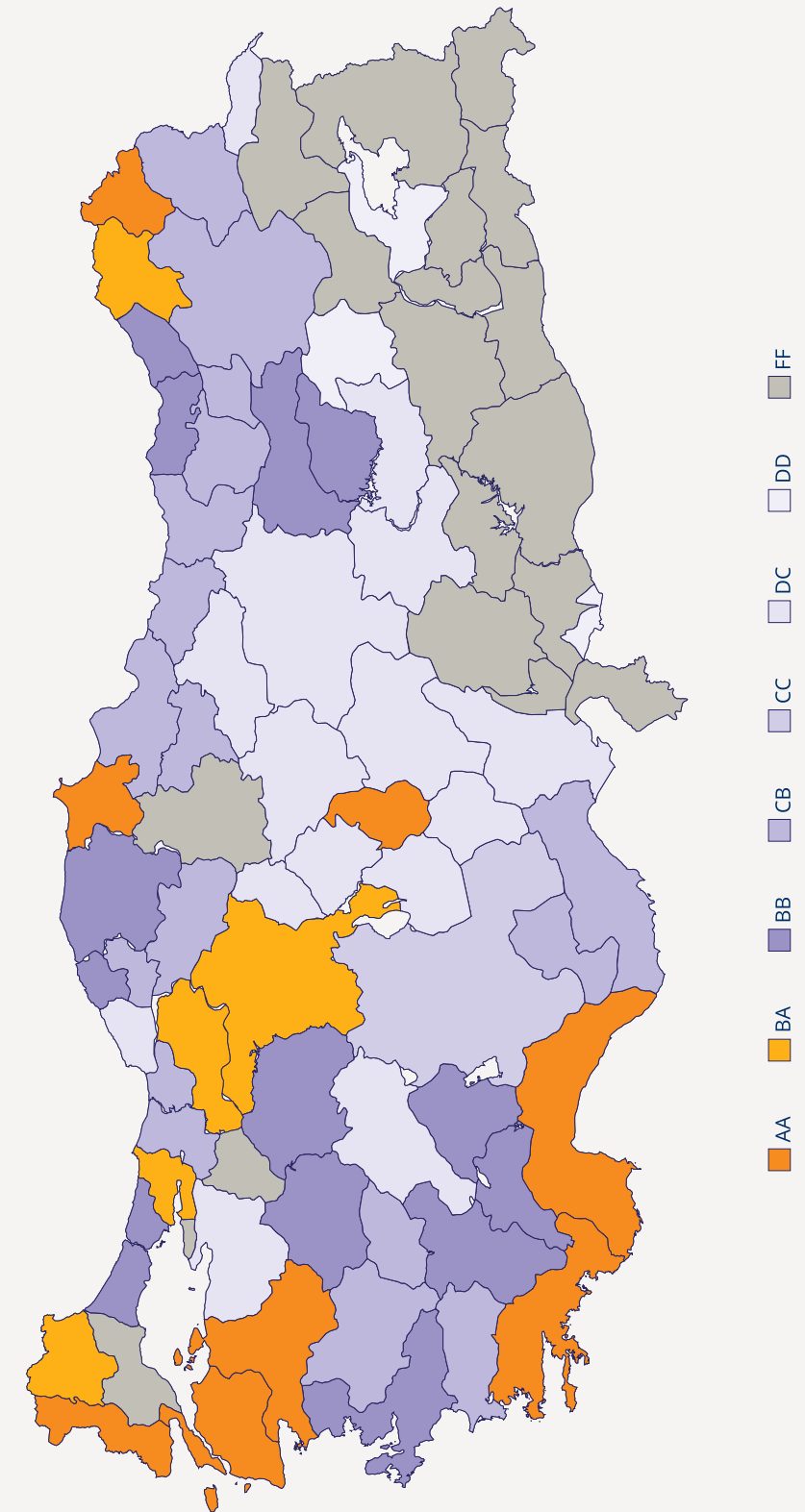


Table 3.2 shows that Muğla and Antalya clearly stand out in this sub-index. Both provinces rank among the strongest in Türkiye in terms of quality-of-life indicators; they perform significantly above the national average in indicators such as access to healthcare services, social life diversity and environmental quality. High life satisfaction and a variety of cultural and recreational opportunities in Muğla enhance the province's attractiveness. Antalya, on the other hand, can be said to have a broad social life profile in due reason of both its tourism-oriented service infrastructure and international population mobility. The rating distribution in Figure 3.10 also supports these findings; both provinces are in the top categories and maintain their leadership in this area.

The geographical distribution of the Quality of Life and Workforce Attractiveness sub-index is shown in Figure 3.10 and it can be seen that the provinces located especially in the western and southern coastal regions stand out in this area. Many provinces in the Aegean and Mediterranean regions are above the national average in terms of social living standards, education and health indicators, immigration trends and working conditions; in contrast, quality of life indicators appear to be more limited in the Central Anatolia, Black Sea and Eastern-Southeastern Anatolia regions. This spatial distribution plays a decisive role in the regional mobility of skilled labor.

Nevertheless, the data from this sub-index also shows that a high quality of life alone does not translate into high technological capacity. Antalya is a strong example of this. The quality of life and workforce attractiveness sub-index in Antalya is one of the factors that contributes most to the province's overall index score; however, its lower performance in the Research and Innovation Capacity and Technology Outputs sub-indices limits the overall score. This situation shows that Antalya's technological capacity is not aligned with its quality-of-life advantage and that technology-based activities have not yet sufficiently benefited from this advantage.



Table 3.9. Transitions from 2024-2025 According to ASO-İLTEK Quality of Life and Workforce Attractiveness Sub-Index

		2025 Quality of Life and Workforce Attractiveness Rating							
		AA	BA	BB	CB	CC	DC	DD	FF
2024 Quality of Life and Workforce Attractiveness Rating	AA	5							
	BA								
	BB		1 ↑	3	1 ↓				
	CB								
	CC				3 ↑	5	22 ↓	↓	1 ↓
	DC					4 ↑	4	31 ↓	↓
	DD					31 ↑	↑	9	1 ↓
	FF							12 ↑	20

Note: Rank decreases are shown in red, and increases in green. The gray area shows the number of provinces that have maintained their rank.

The rating transitions in Table 3.9 show that this sub-index experienced declines during the 2024-2025 period particularly in the middle segment. Some provinces in categories CB and CC have been downgraded to a lower category due to changes in wage levels, employment rates, or cost of living; however, mobility in the higher categories has remained limited. The main reason for the limited upward movement in this sub-index is that the structures that determine quality of life do not change easily in the short term; in particular, urban infrastructure, social facilities and urbanization indicators require long-term investments.

Overall, the Quality of Life and Workforce Attractiveness sub-index reveals that the difference between provinces and those with high technological capacity is shaped not only by production and innovation indicators but also by the spatial distribution of skilled labor. The prominence of provinces like Antalya and Muğla in this sub-index indicates that Türkiye has regional diversity in attracting talent; however, these provinces have not yet sufficiently established the necessary R&D infrastructure for their technology ecosystems. In contrast, the strengthening of quality-of-life indicators as well as R&D and production capacity in provinces such as Ankara, Izmir, Bursa and Kocaeli make these provinces stronger candidates for technology-driven growth.

This table shows that Türkiye's technology ecosystem should be evaluated not only in terms of economic and production indicators but also in conjunction with the living conditions of its skilled workforce; it provides an important framework for understanding the long-term dynamics of regional technology disparities.



TECHNOLOGY THEME: DEFENSE INDUSTRY TECHNOLOGIES

“ In this era where global power balances are being reshaped through technology, the decisive role of defense industry technologies has determined the thematic focus of this year’s ASO-İLTEK. ”

The central role of defense, aviation and space technologies in the 2025 strategic agenda should not be seen merely as a conjunctural response to geopolitical crises such as the Russia-Ukraine War. This reflects a profound paradigm shift where advanced technology serves as a leverage for national economies. The defense industry is no longer just a logistics provider for armies; it has become an incubator for cutting-edge technologies, ranging from artificial intelligence and quantum computing to next-generation materials and space technologies. Focusing on this transformative impact, the Ankara Chamber of Industry has decided to give its "Technological Development Index of Provinces" report series a new corporate identity, designating a "Technology Theme" each year starting with this issue. Due to its global and technological significance, the theme of our 2025 report has been chosen as "defense industry technologies." In the specific case of Türkiye, this topic is important not merely as a matter of increasing military capacity but as a concrete manifestation of the country's pursuit of strategic independence and its high value-added export targets.

This section of the report aims to provide a comprehensive analysis of this paradigm shift in the defense sector. First, the structural dynamics and technology-driven transformation behind record-high global defense spending are examined. The report then examines

¹The concept of "strategic independence" referred to here means a state's capacity to make and implement its own decisions in critical areas concerning its national security, without being dependent on the approval, support, or technology of external actors.

the concrete data and economic impacts of Türkiye's transformation from an import-dependent structure to a technology-exporting power through its "National Technology Initiative" vision in recent years. The latter part continues by evaluating the global competition in critical technologies such as artificial intelligence, hypersonic systems and quantum computing which are rewriting the rules of the battlefield and assessing Türkiye's capabilities in these areas. Finally, Türkiye's integrated defense industry ecosystem is analyzed, and actionable policy recommendations are presented to ensure the sustainability of this success.

This structural transformation in the global security architecture is redefining countries' national power and their positions in the international system. Therefore, understanding the dynamics of the paradigm shift in the defense industry has become a necessity for predicting the strategic environment of the future.

4.1 The Shift in the Global Defense Paradigm: Increased Spending and Strategic Orientations

The expectation of a peaceful post-Cold War era has given way to escalating geopolitical tensions, the supply of new energy sources and the security of supply chain routes, as well as growing regional security concerns. This new era is forcing countries to redefine their defense capabilities and place technological superiority at the center of national security. This section examines the structural dynamics behind record-high defense spending, the technology sectors to which these resources are directed and the institutional mechanisms that are accelerating this transformation.

Record Defense Spending and Structural Transformation

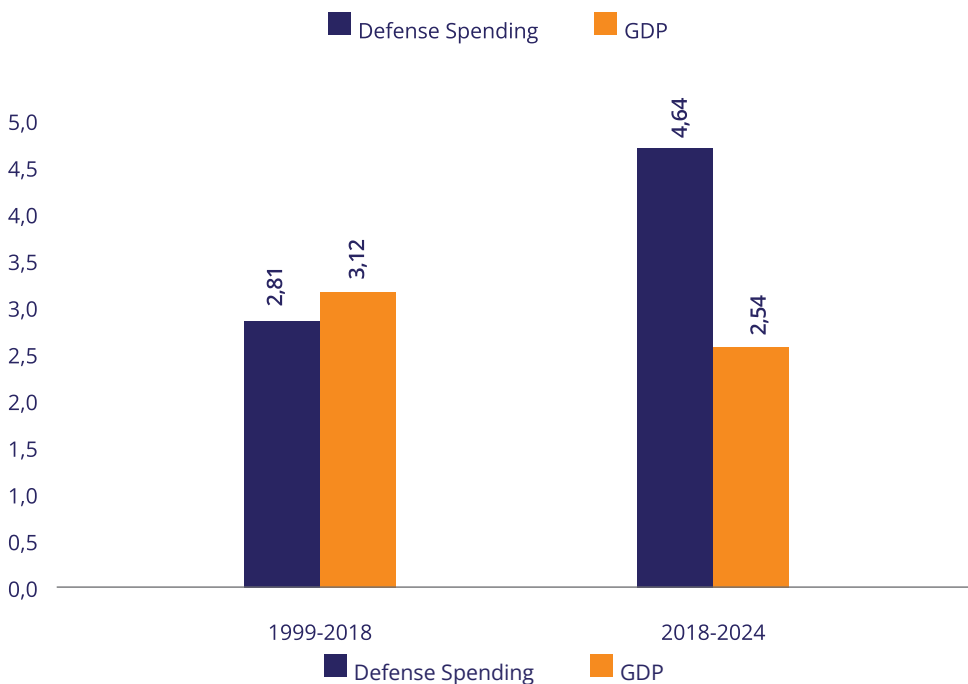
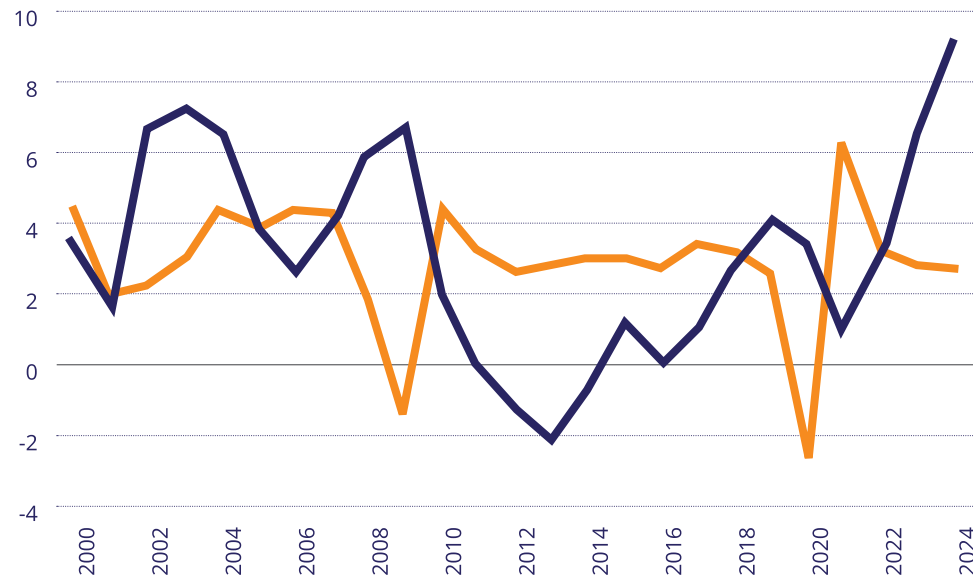
According to data from the Stockholm International Peace Research Institute (SIPRI), global defense spending has risen steadily over the past decade, becoming a structural trend and is projected to reach US \$2.718 trillion in real terms by 2024, representing a 9.4% increase (Liang et al., 2025). This increase is more than a temporary crisis management reflex; it is the financial reflection of a permanent shift in global power balances.



“ The fact that defense budgets are increasing globally at a rate exceeding GDP growth clearly demonstrates that security and technology are once again at the center of national priorities. ”

Regionally, spending in Europe increased by 17% to \$693 billion, while spending in the Middle East increased by 15% to \$243 billion. The fact that NATO members' collective spending exceeds \$1.5 trillion indicates that the Western bloc has once again placed conventional deterrence at the center of its strategic agenda (Liang et al., 2025).

Figure 4.1. Annual Growth Rate (%) of Global GDP and Defense Expenditures

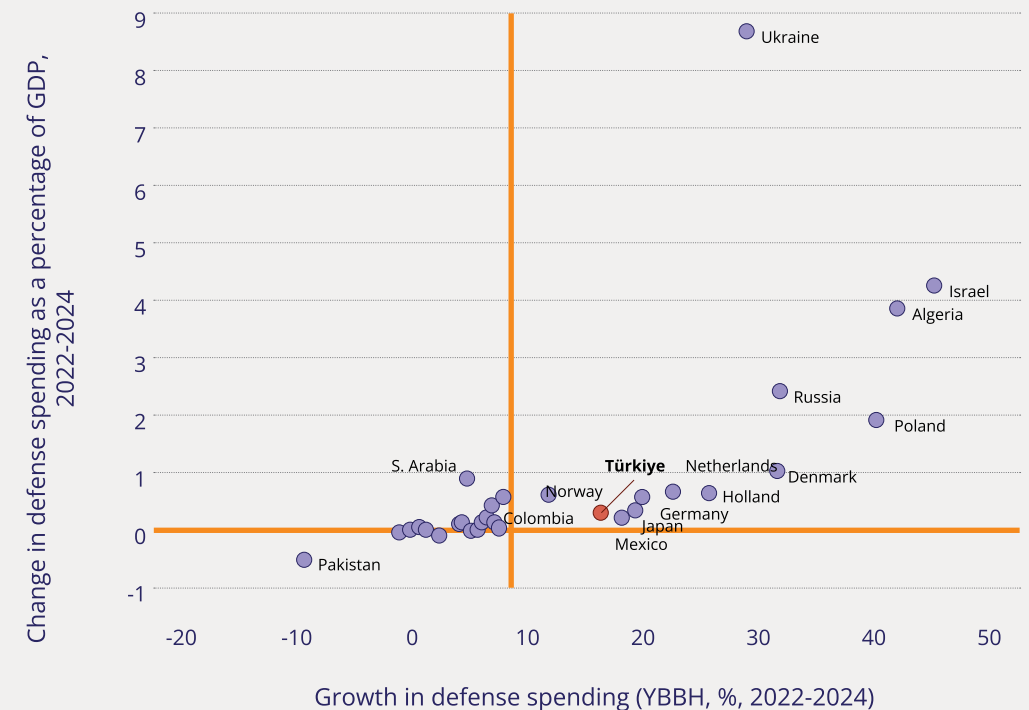


Source: World Bank, SIPRI. Note: The graph showing period averages includes compound annual growth rates.

The structural nature of this trend is undeniable. For the first time in the post-Cold War era, growth in defense spending is significantly outpacing global GDP growth. As shown in Figure 4.1, this trend has led to defense spending as a percentage of GDP reaching 2.44% (SIPRI, 2025a). This difference signals a fundamental shift in national priorities; resources are being reallocated from other sectors towards security. This situation demonstrates that states tend to make concessions in economic and social areas to achieve technological and military deterrence.

This increase in spending is not a phenomenon limited to a particular region. As shown in Figure 4.2, the increase observed in most of the 30 largest economies, which account for 90% of global defense spending, confirms that this rise is a global phenomenon and that the trend is structural. Although SIPRI indicates that 59.2% of the increase between 2022-2024 occurred in the Europe and Middle East regions (SIPRI, 2025), the fact that increases are actually occurring in all regions indicates that scaling up in defense technologies is a structural rather than a cyclical trend.

Figure 4.2. Changes in the Growth Rate of Defense Expenditures and Defense Expenditures Ratio to GDP



Source: SIPRI.

Note: The 30 countries included in the graph accounted for 90% of global defense spending in 2024. Defense spending decreased in real terms in three countries (Italy, Brazil, and Pakistan) during the 2022-2024 period, while it increased below the global growth rate in 14 countries and above it in 13 countries. The orange threshold on the -x axis of the graph represents the 8% growth rate of global defense spending during that period. CAGR stands for Compound Annual Growth Rate.

Corporate Mechanisms That Accelerate Technology-Focused Innovation

Increased budgets are being directed not only towards the modernization of existing systems but also towards new multinational institutional structures that accelerate the transition of disruptive technologies from the laboratory to the field. These mechanisms accelerate the race for technological superiority by facilitating the adaptation of civilian innovation to military needs.

- **NATO DIANA (Defense Innovation Accelerator for the North Atlantic):** It is an accelerator program that supports early-stage technology startups in the defense sector with test and validation networks. This structure aims to facilitate the entry of civilian startups into the defense market.
- **NATO Innovation Fund (NIF):** With a size of at least 1 billion euros, it holds the distinction of being the world's first multinational venture capital fund. The fund enables NATO allies to directly invest in deep-tech startups operating in fields such as artificial intelligence, quantum and autonomous systems.
- **European Defense Fund (EDF):** With a cumulative commitment volume reaching €5.4 billion, this fund aims to enhance the strategic autonomy and industrial competitiveness of EU by financing joint R&D projects.

The global financial and institutional framework is fundamentally changing technology development and procurement processes in the defense industry. This new ecosystem offers a critical foundation for understanding how emerging actors like Türkiye are shaping their strategies and positioning themselves in global competition.

4.2. Türkiye's Strategic Rise: From Technological Independence to Global Competitiveness

“Türkiye's transformation from an importer to a technology exporter in the defense industry signals a strategic rise that redefines not only the country's security capabilities but also its global competitiveness.”

Türkiye's current position in the defense industry is the result of a planned strategic evolution spanning decades. The sector, which before 1990 was largely based on "ready-made purchases" and reliant on foreign capital, shifted to a "joint production" model between 1990 and 2000, aiming to increase the rate of domestic contribution. Since the early 2000s, the acquisition of "partial design" capabilities and the adoption of the "local main contractor" model have laid the foundations for sectoral deepening. This process matured with the transition to the "original design" phase between 2010-2020 and has since evolved into a "product and technology ownership" vision focusing on basic and advanced technologies today (SSB, 2024).

Building upon this historical legacy and accelerating in recent years with the "National Technology Initiative" vision, Türkiye has transformed from a dependent importer into an ecosystem that produces, develops and exports its own technology to global markets. This achievement has not only enhanced national security capabilities but has also become a strategic asset that expands Türkiye's room for maneuver in foreign policy. This section analyzes the consequences and economic implications of this strategic rise.

Proof of Strategic Independence with Data

The data clearly reveals the shift in Türkiye's position in the global arms market. Comparing the periods 2015-2019 and 2020-2024, Türkiye's arms exports increased by a striking 103%, while arms imports decreased by 33% during the same period (Djokic et al., 2025). This shift has propelled the country to become the world's 11th largest arms supplier while also serving as concrete evidence of its goal of strategic independence.

The export performance of the defense and aerospace industry is the driving force behind this growth. According to TİM data, the defense and aerospace sector's exports are expected to reach 6.7 billion USD in 2024, accounting for 2.98% of total merchandise exports; projected to continue their upward trend in the first ten months of 2025 reaching 3.44% of total merchandise exports. This demonstrates that the sector now plays a structural, rather than cyclical, role in the country's economy. The fact that the domestic production rate in the defense industry is expected to rise to 84% by October 2025 shows that the sector is not limited solely to the production of final platforms; it also demonstrates the formation of a broad-based supply ecosystem (MÜSiAD, 2025a). Especially in critical subsystems such as engines, achieving this ratio at levels of 90-95% is the most important guarantee of the sustainability of the ecosystem (MÜSiAD, 2025b).

The Economic Significance of High Added Value

The success of the Turkish defense industry is defined more by quality than quantity. The most important indicator of the added value created by the sector is the export value per kilogram. According to TİM's export data, in the defense and aerospace industry, this value exceeded 65 USD in 2024, reaching approximately 44 times the average overall export value of 1.57 USD for Türkiye. This striking difference reveals the sector's knowledge-intensive and technology-driven nature and proves its leading role in Türkiye's strategy to escape the "middle-income trap."

“The high value-added exports and globally recognized company performance of the Turkish defense industry demonstrate that Türkiye has entered a value-added transition period in its technology-based competitiveness.”

Table 4.1. Turkish Companies Included in the Defense News Top 100 List

Company	Rank (100 Countries)		Defense Income (Billion USD)	
	2024	2025	2024	2023
Aselsan	42	43	3,54	2,90
TAI	50	47	3,15	2,21
Roketsan	71	71	1,55	1,76
MKE	84	80	1,21	0,88
ASFAT	94	78	1,28	0,64

Source: [defensenews.com](https://www.defensenews.com).

The increasing global recognition of Turkish companies is another dimension of this success. Five Turkish companies are included in the Defense News Top 100, one of the most prestigious international lists. As shown in Table 4.1, three of these companies (TUSAŞ, MKE and ASFAT) rose in the rankings over the past year while Roketsan maintained its 71st position and Aselsan dropped one place to 43rd in the 2025 list. Thus, the average ranking of these five defense companies in the top 100 list was 68.2 in 2024 and 63.8 in 2025. On the other hand, the total revenue these five companies generated from their defense activities increased by 28% from 2023 to 2024.

The sector's growing global importance is also confirmed by the Stockholm International Peace Research Institute's (SIPRI) data from December 2025. In SIPRI's ranking of the world's top 100 defense companies, Türkiye has reached its highest ever representation with five companies included in the 2024 list. This year while the total defense revenues

of the top 100 companies increased by 5.9%, the revenue of Turkish defense industry companies grew by 11% reaching US \$10.1 billion (SIPRI, 2025b).

According to 2024 data, with five companies on the list Türkiye has risen to become the fourth country with the most companies after the USA (39), China (8) the United Kingdom (7) and Japan. In a comparison of the 13 main players that hold more than 1% of the global market share, Türkiye ranked seventh in terms of income growth rate proving its rise in global competitiveness (SIPRI, 2025b).

Ranked 47th on this list, ASELSAN increased its revenues by 24% while the decisive factor in this growth being the exports showing a 65% increase. Ranked 73rd on the list, Baykar has demonstrated the most concrete example of an "export-oriented growth" model by generating 95% of its total revenue from exports. In addition, MKE (17%), Roketsan (13%) and TUSAŞ (11%) continued to expand Türkiye's share in the global market with double-digit growth rates (SIPRI, 2025).

Figure 4.3. Distribution of Countries in the SIPRI Top 100 Defense Companies List



Source: SIPRI (2025b). Countries with a share of less than 1% of the revenue of the top 100 companies were excluded.

This impressive performance stems not only from platform production but also from expertise in disruptive technologies that will shape the future of warfare. The next section will examine these technological capabilities and their place within global trends in detail.

4.3. Critical Technology Areas: Global Trends and Türkiye's Capabilities

The modern battlefield is shaped not only by physical platforms but also by disruptive technologies that process data, accelerate decision-making and increase the range of their impact. From artificial intelligence to hypersonic systems, from directed energy to quantum sensing, these new technologies are fundamentally changing the nature of warfare. This section summarizes the global competition in each critical technology area and then evaluates Türkiye's concrete projects and capabilities in these areas.

“As new generation defense technologies reshape the global balance of power, Türkiye has become one of the few countries demonstrating competence in critical areas of this transformation.”

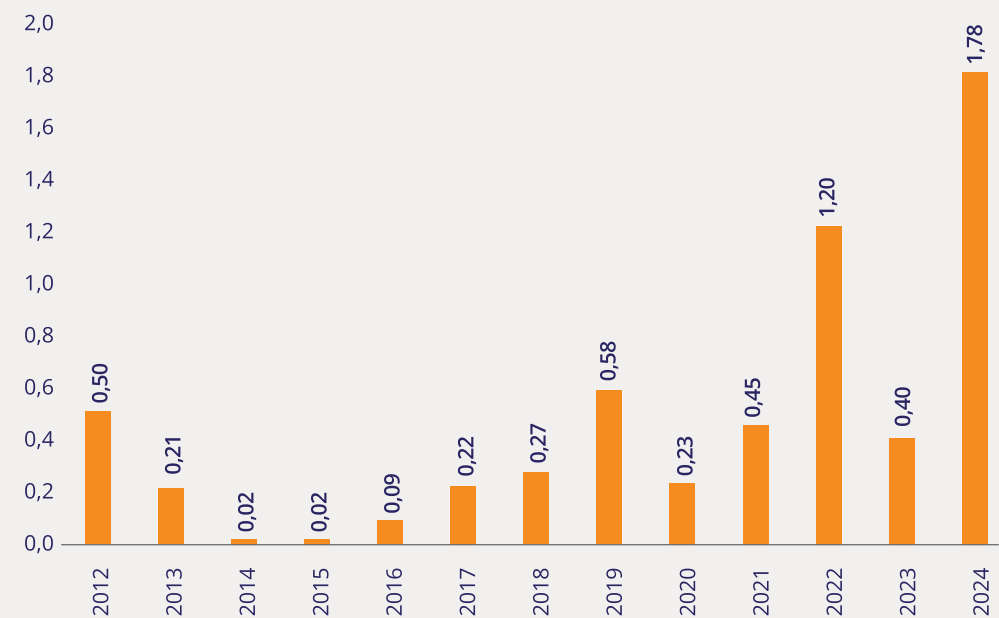
Artificial Intelligence: The Nervous System of Modern Warfare

Artificial intelligence, the field experiencing the most significant leap in technology also forms the basis of modern defense architectures. In the 2024-2025 period, artificial intelligence is approaching operational standardization in command and control, reconnaissance and surveillance, target detection, mission planning and modeling-simulation layers. RAND indicates that artificial intelligence has the potential to shorten the decision cycle, reduce human bias and increase situational awareness in force planning, engagement activities and intelligence preparation processes; however, it emphasizes that human involvement and traceability principles are critical (Burdette et al., 2025). McKinsey assessments indicate that commercial-military convergence is rapidly raising maturity levels along the AI-composite-sensing-quantum axis, creating a frontier of a modern defense sector worth approximately US \$250 billion (McKinsey & Company, 2025). OECD data shows that support allocated to AI initiatives in the defense sector has

²Founded in 1948, the RAND (Research and Development) Corporation is a US-based, non-profit, non-partisan research institute that produces data-driven analyses in the areas of national security, international relations and public policy.

also increased. Venture capital investments focused on AI in the public, security and defense sectors averaged US\$306.2 million annually between 2017-2020, rising to US\$1.51 billion between 2021-2024. Compared to the 2017-2020 period, global venture capital investments focused on artificial intelligence increased 1.76 times in the 2021-2024 period, while the same ratio was 4.94 times in the public, security and defense sector. This situation is also reflected in the share of the public, security and defense sectors within global AI-focused venture capital investments presented in Figure 4.4. This share has approached 1.8% as of 2024. Thus, private capital has now placed this technology at the heart of the battlefield of the future.

Figure 4.4. Share (%) of Public, Security and Defense Sectors in AI-Focused Venture Capital Investments



Source: OECD.AI Policy Observatory.

Türkiye is taking significant steps to integrate AI into its most strategic platforms. The domestically produced combat aircraft KAAAN and the unmanned combat aircraft KIZILELMA are equipped with AI-based mission systems. In particular, the efforts to control KIZILELMA with voice commands using T3 AI, Türkiye's national large language model, reflects the importance on hardware and software integration (Özdemir, 2024).

Hypersonic Systems: A New Era in Speed and Deterrence

Hypersonic weapons, capable of maneuvering through the atmosphere at speeds five times the speed of sound, have the potential to render existing air defense systems ineffective due to their unpredictable trajectories. However, this technology brings with it significant engineering challenges.

Türkiye is also making progress in this strategic area with concrete projects:

- **TAYFUN Blok-4:** Developed by ROKETSAN, this new generation ballistic missile with an estimated range of 800-1000 km aims to elevate Türkiye's regional deterrence to continental level.
- **GÖKHAN:** It is Türkiye's first ramjet-propelled air-to-air missile developed by TÜBİTAK SAGE. The ramjet engine uses oxygen from the atmosphere to provide the missile with long range (100 km+) at speeds of Mach 4+ and high maneuverability in the terminal phase.

“ The rapid leap in critical defense technologies is reshaping the global power architecture and Türkiye is becoming a visible actor in this strategic race with its hypersonic systems, directed energy solutions, “New Space” satellites and quantum infrastructure. ”



Directed Energy and Electromagnetic Weapons

Laser and high-power microwave weapons are considered the most effective solution, especially against asymmetric threats such as drone swarms, due to their “cost per shot” advantage and ability to intercept at the speed of light (Congressional Research Service, 2023). Türkiye is among the few countries that have developed operational prototypes in this field.

- **ALKA (ROKETSAN):** Offers a hybrid solution capable of both physically destroying drones and disabling their electronic systems, owing to its 50-kW laser and electromagnetic jamming system.
- **GÖKBERK (ASELSAN):** With its 5-kW laser, it provides cost-effective protection against mini/micro-UAVs by forming the lowest layer of a layered air defense architecture.
- **ŞAHİ-209 (YETEKNOLOJİ):** This 10-megajoule electromagnetic railgun demonstrates a groundbreaking capability in gunpowder-free weapon technology by launching ammunition at hypersonic speeds (Mach 6+) to a range of 50 km.

New Space: Strategic Competition in Orbit

The concept of “New Space” refers to distributed and resilient architectures consisting of thousands of small, low-cost satellites placed in Low Earth Orbit. These architectures are more resistant to anti-satellite missiles. However, the increase in satellite traffic in orbit brings with it the need for space situational awareness and the risk of Kessler Syndrome (collision chain).

In this field, Türkiye is distinguished by the dynamism of the private sector. Baykar subsidiary Fergani Space's goal of establishing a global positioning and communication constellation and Plan-S's development of Internet of Things (IoT) satellites, represent Türkiye's “New Space” presence in the world. In addition to these initiatives, GSATCOM, a subsidiary of TUSAŞ is taking its strategic competence in this field to the next level with its “Small GEO” product family, developed jointly with Argentina. These new generation communications satellites with their fully electric propulsion system and flexible payload architecture, offer cost-effective solutions and play a significant role in Türkiye's export of high value-added satellite systems (SSB, 2024).



Quant / TOBB University

Quantum Technologies: The Future of Cognition and Computing

Quantum technologies have the potential to revolutionize the defense industry on two main fronts: Quantum Computing (breaking existing encryption systems) and Quantum Sensing (precise navigation even in environments where GPS is unavailable or jammed).

Developed by TOBB ETÜ, Türkiye's first quantum computer, QuantT, with its 5-qubit capacity, represents a fundamental step for Türkiye in this strategic field and embodies the country's ambition to be not just a consumer but also a producer in future technologies. The geographical distribution and integration of the industrial infrastructure that produces and develops these advanced technologies is critical for the sustainability of success.

4.4. Türkiye's Defense Industry Ecosystem: Clusters and Geopolitical Role

Türkiye's success in the defense industry is not the result of coincidental developments; it is the product of an integrated clustering structure that specializes in specific geographical regions, increases in efficiency and accelerated information flow. This structure creates synergy by bringing together all stakeholders from main contractors to SMEs and universities to research centers.

Specialized Clusters and Strategic Division of Labor

Türkiye's defense industry ecosystem is clustered around four main centers. Each center specializes in specific technology areas, creating a strategic division of labor.

Table 4.2. Defense Clusters in Türkiye

Clustering Center	Role and Expertise Area	Key Features and Leading Companies/ Institutions	Focus Technologies
Ankara (The Brain of the Sector)	Design, Development and System Integration	Headquarters of the main contractors (TUSAŞ, ASELSAN, ROKETSAN, HAVELSAN) and the Presidency of Defense Industries (SSB). Strong systems engineering infrastructure.	Systems engineering, command and control (C4ISR), radar and electronic warfare, missile technologies.
Istanbul/Marmara (Supply Chain and Innovation Center)	Mass Production, Supply Chain, and Digital Innovation	SAHA Istanbul leads the way with over 1000 companies. Shipyards (MILGEM), and private sector giants like Baykar.	Naval platforms (MILGEM), unmanned systems (UAV/UCAV), software and artificial intelligence.
Eskişehir (Aviation Engines Base)	Engines, Propulsion Systems and Precision Manufacturing	Production of aviation engines and parts under the leadership of TEI. Center for domestic engine projects such as TF6000 and TS1400.	Turbofan/turboshaft engines, precision casting, critical propulsion systems.
Konya & Kırıkkale (Weapons and Ammunition Valley)	Land Systems, Weapons and Ammunition Manufacturing	A well-established industrial infrastructure in traditional weapons and ammunition production, involving both MKE and private sector firms.	Light/heavy weapons, ammunition, armored land vehicles, air defense simulation

Türkiye's defense industry vision has the potential to evolve into a three-tiered hierarchical structure where Ankara acts as the "brain," undertaking high value-added processes such as design and system integration; Eskişehir and Kırıkkale specialize in engine and ammunition production; and new centers, such as disaster-stricken areas, transform into qualified supply bases. However, when formulating a strategy for transitioning to this ideal structure, the concept of "cluster maturity" must be considered as a critical variable.

“The defense technology cluster, which has matured under Ankara's leadership has begun to create a sustainable technological structure for Türkiye that provides both regional deterrence and extends to the civilian economy.”



The most concrete and current manifestation of this vision is the Oğulbey Technology Base investment, focused on the "Steel Dome," which gained momentum in the last quarter of 2025 and is being implemented in Gölbaşı, Ankara, under the leadership of ASELSAN. This facility, the largest single defense industry investment in the history of the Republic, will be the epicenter of Türkiye's 'System of Systems' approach, which integrates layered air defense architecture under a single AI-powered network. Planned to be Europe's largest integrated air defense facility, this complex confirms the thesis that Ankara is not just a production center but the brain of a strategic defense architecture. Expected to provide employment for approximately 4,000 qualified personnel, the project will deepen engineering capacity in radar and electronic warfare while also creating a technological leverage effect for hundreds of local SMEs that will be integrated into the project.

On the other hand, global indices show that Ankara, despite its leadership in the defense sector and its position as a hub, is still far from its potential in overall technology ecosystem rankings (243rd according to Dealroom data) and in deep technology capabilities (artificial intelligence, chip manufacturing, etc.). For an industrial cluster to be able to supply surrounding provinces by creating a spillover effect, it must first complete its internal vertical and horizontal integration by reaching its "saturation point".

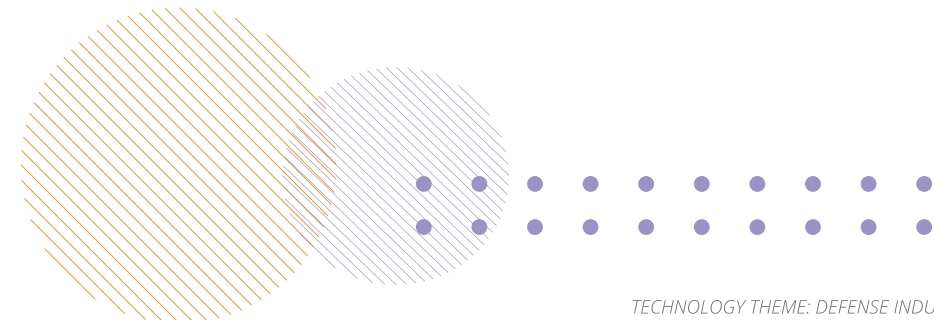
Currently, before Ankara has reached this level of maturity, the intensive redirection of limited resources to new production centers such as those in disaster-stricken areas, risks slowing down the development momentum of the main cluster. This situation "early decentralization" (early expansion) situation may delay Ankara's transformation into a Silicon Valley-like structure capable of competing with its global rivals. Therefore, while implementing investments in disaster-stricken areas, investments that will increase Ankara's R&D and technological depth should not be sacrificed; on the contrary, a phased growth strategy should be adopted with the principle of "strengthened center first, then competent periphery".

Geopolitical Implications of Technological Capacity

Türkiye's increasing technological capacity has become an important tool of influence in its foreign policy. According to research, Türkiye's most important partners in technological cooperation are Turkic states with the main focus being defense technologies (Özdemir, Akıllı, & Uslu, 2025). This demonstrates that Türkiye effectively utilizes its technological expertise to strengthen regional alliances and increase its geopolitical influence.

However, Türkiye's position within NATO faces a structural asymmetry problem. Although the country is one of the members that contributes the most to the alliance's military operations, it does not have a proportionate influence in decision-making processes. This situation creates an imbalance that experts describe as "high responsibility and limited decision impact" (Kılıç, 2025). Türkiye's efforts to increase technological independence and industrial capacity also serve the goal of breaking this asymmetry and increasing its strategic weight within the alliance.

The impact of the defense industry is not limited to military and geopolitical fields alone. The developed advanced technologies are spreading into the civilian economy making significant contributions to overall welfare improvements.



4.5. Spill-Over Effect: Technology Transfer from the Defense Industry to Civilian Welfare

Contrary to popular belief, investments in the defense industry do not create a "war economy," but rather act as a catalyst that increases overall economic efficiency through the spin-off of advanced technologies into civilian sectors. A study by Moretti et al. (2025) demonstrates that state-sponsored defense R&D, in particular stimulates private sector productivity and innovation.

“ The defense industry is not just a sector where developed technologies are transferred to the civilian sector; it is a multi-layered diffusion mechanism that can transform the real sector through technology, human resources and quality standards. ”

The contribution of the defense industry to the national economy and technological development is often evaluated in the literature and public opinion only through the commercialization (spin-off) of military technologies in the civilian sector. However, reducing the spillover effect created by the defense industry solely to the transfer of the final product leaves out a deeper understanding of the ecosystem. To fully analyze the added value created by the sector, it is necessary to address the process holistically across five fundamental layers: technology transfer, human resources, industrial standards and macroeconomic balances.

At the first and most fundamental level of this interaction lies the technological principle of "dual-use." High-quality technologies emerging from laboratory settings, driven by the demanding nature of military requirements, eventually find their counterparts in civilian life. Lightweight and durable composite materials (such as carbon fiber) developed for ballistic protection have become a critical input for fuel efficiency in the civil aviation and automotive sectors today. Similarly, precision radar and lidar systems developed for missiles and UAVs form the basis of the environmental sensing capabilities of autonomous vehicles; while advanced battery technologies developed to meet the energy needs of soldiers in the field or to extend the underwater time of submarines are being integrated into and spreading to civilian electric vehicles and mobile devices.

Beyond technological transfer, at the second level, the defense industry functions as an "industrial quality and standards school," transforming the production culture. When main contractors push SMEs in their supply chains to comply with stringent military standards like Mil-Spec or AS9100, it creates a quality leap across the industry. A workshop that achieves micron-level precision and certification discipline while producing a tank part can transfer this expertise to areas requiring high precision, such as medical devices or nuclear power plant components. In addition, critical infrastructure such as wind tunnels and electromagnetic testing centers established for the defense industry are being opened up for use by civilian sectors enhancing the ecosystem's testing and certification capabilities.

The third layer, built upon this infrastructure and technology foundation is the sectoral spin-off effect which is the most well-known phenomenon in the public eye. This is where specific solutions developed in the defense industry are commercialized and transformed into new products or companies in the civilian market. In Türkiye, this sectoral transitivity is demonstrated with concrete and successful examples in fields such as healthcare, energy and civil security.



• Health Technologies and an Example of Industrial Mobilization During a Pandemic:

The COVID-19 pandemic has been the clearest evidence of the Turkish defense industry's ability to mobilize industrially in times of crisis. The domestically designed ventilator (Biyovent), developed by BIOSYS, could not be brought to life due to a lack of mass production infrastructure. At this point, defense industry giants stepped in: ASELSAN mobilized its electronic circuit and testing capabilities, BAYKAR its software and systems engineering expertise and ARÇELİK its mass production line for this project. Thanks to this collaboration, mass production was initiated in record time, resulting in the production of over 20,000 devices, which were then exported to more than 30 countries. Moreover, ASELSAN has specialized in the field of Mobile Digital X-ray devices by transferring its deep experience in military imaging systems to healthcare technologies.

As a result of this strategic orientation, the company concluded the largest single-item domestic sales contract in the healthcare sector with an agreement worth approximately US \$26.1 million signed in November 2025 (Yıldırım, 2025). Additionally, the Heartline OED (Automated External Defibrillator) device developed by ASELSAN is the most direct reflection of the defense industry's electronic design expertise in the civilian sector. Saving lives in sudden cardiac arrests, this device is becoming widespread in public spaces from airports to campuses. It is the most concrete proof that the industry is producing technology not only for the front lines but also for daily life safety.

“ The transfer of technological capabilities developed by ASELSAN, BAYKAR, ARÇELİK and ASPİLSAN to the health, energy, cybersecurity and mobility sectors demonstrates that the defense ecosystem is beginning to transform into a mechanism of diffusion into other sectors. ”



ASPİLSAN Cell and Battery Systems Production Facility / Kayseri

• Synergies with the Energy and Mobility Sectors:

ASPİLSAN Energy, based in Kayseri, has successfully transferred its lithium-ion battery technology, developed for military platforms, to the civilian sector. Having established one of Europe's first cylindrical lithium-ion battery production facilities, the company leverages this expertise to supply domestically produced cells to both the household electric appliance market and micromobility vehicles. More importantly, ASPİLSAN and other defense companies' in-depth expertise in battery management systems (BMS) makes a significant contribution to increasing the capacity of energy storage systems (ESS) which are critical for renewable energy integration and reducing Türkiye's dependence on foreign sources in this field (Aspilsan, 2024).

• Civil Security: Protecting the Green Homeland with UAVs:

Unmanned aerial vehicles (UAVs) are used in Türkiye to combat forest fires. UAVs such as the Bayraktar TB2 and AKSUNGUR play a critical role in protecting our forests due to their high-resolution thermal cameras and uninterrupted data transmission capabilities. Early detection of 4091 forest fires between 2020 and 2024 was made possible with the help of these systems (Baykar, 2025). This is one of the most successful examples in the world of the direct use of a military platform for civilian public safety. The sustainability of these achievements and the implementation of similar projects in the future are crucial.

Beyond the product and company-based outputs, the ecosystem's fourth and most strategic output is human capital. Defense projects serve as a training ground, creating a pool of qualified personnel with a strong understanding of complex systems engineering. Engineers trained here eventually establish their own ventures, bringing civilian technology companies to life and nourishing the country's startup ecosystem (also supporting it through remigration of brain drain). In addition, supporting basic science research at universities with defense funding enables academia to develop capacity for civilian research as well.

Finally, the macroeconomic and strategic layer demonstrates the multiplier effect of all these processes on the national economy. Critical capabilities gained in the defense industry, such as turbine engine production, provide import substitution by reducing external dependence in the energy and transportation sectors. The high export value per kilogram in the sector, along with the spread of this production culture, contributes to shifting the country's overall export profile from cheap or low value-added products to high value-added and technological products.



AKSUNGUR / TAI

4.6. Future Vision and Strategic Policy Recommendations

Sustaining Türkiye's success in the defense industry requires not only completing existing platform projects but also establishing a flexible, proactive and visionary governance architecture to manage next-generation technologies. This vision should involve drawing lessons from global models and implementing concrete policies that realize a long-term strategic transformation to enhance Türkiye's technological superiority.

Lessons to be Learned from Global Innovation Models

The project management model centered around the Presidency of Defense Industries (SSB) has brought Türkiye to its current position in the field of defense industry. However, the speed and flexibility required by next-generation AI and software-driven warfare technologies necessitate an evolution of the current model's hardware-centric structure. Table 4.3 provides a general overview of different prominent models in global defense innovation and the aspects from which Türkiye can learn from these models.

“ The robust supply chain structure of the defense industry can create an effective ecosystem through risk-taking, rapid prototyping and widespread innovation and entrepreneurship models. ”

The global examples presented in Table 4.3 demonstrate that defense innovation cannot be reduced to a single, uniform template; rather, each country establishes hybrid structures shaped by its own strategic priorities. Although Türkiye, under the leadership of the Presidency of Defense Industries (SSB), has proven its capabilities in platform-focused projects (UAVs, ships, helicopters), the current model has not yet achieved the desired flexibility in terms of deep technology and civil integration.

However, the current structure has gone beyond merely functioning as a procurement authority and has also implemented pioneering mechanisms that support industrial and technological development. Through its subsidiary SSTEK A.Ş., SSB plays an active role in the establishment and funding of technology companies operating in critical and advanced technology sectors, acting as a catalyst in areas where the private sector finds it difficult to enter. While the physical infrastructure of the ecosystem is strengthened

with initiatives such as Technopark Istanbul, the technical and institutional competencies of SMEs are systematically increased through the Industrial Competence Assessment and Support Program (EYDEP). Furthermore, talented firms from all over Türkiye have been brought together with main contractors and integrated into the defense supply chain, creating a sustainable production base defined as a "pyramid structure". Therefore, while the areas for development in deep technology and civilian integration remain, it is evident that the institutional foundations to enable this transformation have been laid (SSB, 2024).

The maturation of these established mechanisms is vital for adapting to changing war doctrines. This is because the hybrid warfare environment of the future necessitates not only platform production but also the software that empowers these platforms, the agility of the startup ecosystem and qualified human capital. In this context, the UK's grassroots approach to integrating SMEs into the system, the US's risk-taking R&D culture and Israel's human-resource-centric selection system are complementary to Türkiye's current model focused on large contractors. Therefore, the roadmap needed to consolidate Türkiye's technological advancement is based on synthesizing these global lessons with national realities.



MAM-C (3) / ROKETSAN

Table 4.3. Defense Models of Countries

Model	Basic Principles	Implementation Mechanism	Implications for Türkiye
USA (DARPA & DIU)	High Risk and Civilian Integration. Funds revolutionary technologies with a high probability of failure and rapidly adapts civilian technology (Silicon Valley) to the military.	It uses structures that are free from bureaucracy, give project managers full autonomy, and rapid prototyping processes.	An autonomous research unit capable of "taking risks" should be established within the SSB (Undersecretariat of Defense Industries), and flexible procurement interfaces can be created for civilian software companies.
UK (DASA)	SME-focused open innovation. It purchases ideas from small businesses and academics outside the defense industry as an "innovation service".	DASA (Defense and Security Accelerator): It consistently provides SMEs with rapid funding through open calls for proposals and connects them with main contractors.	A similar "Defense Innovation Accelerator" could be established in Türkiye to counterbalance the dominance of main contractors and integrate SMEs into the system.
China (MCF)	Civil-Military Fusion (Dual-Use). It makes "dual-use" technologies mandatory through state policy by removing the barriers between the civil and military industries.	State-Driven Integration: Technology from civilian companies in fields such as artificial intelligence and semiconductors is transferred directly to the military.	Türkiye does not yet have an official "dual-use strategy". The transfer of civilian technology to defense needs to be established on a legal and institutional basis.

Model	Basic Principles	Implementation Mechanism	Implications for Türkiye
France (AID)	Strategic Autonomy and Red Teams. They encourage thinking outside the box to overcome bureaucratic inefficiencies while preserving national independence.	AID (Agence de l'Innovation de Défense): It works with a "red team" of science fiction writers to develop future threat scenarios and ensures rapid scalability.	To predict future warfare scenarios (asymmetric threats, etc.), think tanks that incorporate non-engineering disciplines (sociology, futurism) into the process can be supported.
S. Korea (DAPA)	Export-Oriented Industry 4.0 positions the defense industry as a driver of economic growth and places exports at its center.	DAPA (Defense Acquisition Program Administration): By bringing supply and R&D processes under a single umbrella, it minimizes export restrictions and bureaucracy.	For export-oriented growth, mechanisms can be developed to accelerate government-to-government (G2G) sales processes and increase diplomatic support.
Israel (Talpiot)	Innovative Human Capital. It views the source of technological superiority not as a project, but directly as human resources.	Early Talent Management: The brightest young people are selected during their high school years, undergo intensive scientific training and lead R&D teams.	Special programs, starting from high school level can be designed to train deep-rooted technology leaders who will shoulder not only the military but also the national technology drive.
Türkiye (SSB)	Project Management and Localization. Manages large platform projects through main contractors.	It centralizes engineering expertise and project management in the main contractors.	The model is successful but it needs to be supported by more flexible and broadly based funding mechanisms for deep technology.

Source: U.S. Department of State (2020), DAPA website, DASA (2021), ISDP (2024), Ministère des Armées (2024).

Action-Oriented Policy Recommendations for Türkiye

In this context, the following policy recommendations offer a concrete roadmap that goes beyond merely preserving Türkiye's success in the defense industry, aiming to propel the country to the forefront of the global technology race:

“Türkiye's attainment of a lasting advantage in the global technology race necessitates a defense innovation strategy that accelerates defense-civilian integration, focuses on deep technology, prioritizes human resources and institutionalizes a high-risk, high-reward culture.”



1. Deep Technology Leaders Program and Qualified Human Resources: In today's world, where talent is the most critical capital, a "Future Technology Leaders" program should be implemented that trains young people, starting from high school level, to lead both the defense industry and the civilian technology ecosystem. This approach will not only meet the human resource needs of the defense industry; it will also bring entrepreneurial and innovative technology elites vital for Türkiye's overall economic development into the system.

2. Formalization of the National Dual-Use Strategy: Türkiye needs a formal National Dual-Use Strategy that will remove the barriers between its defense and civilian industries. Legal and financial incentive mechanisms should be established to ensure the rapid adaptation of military-developed technologies (e.g., batteries, autonomous driving) to the civilian sector and vice versa. This strategy will ensure that defense spending directly contributes to civilian welfare.

3. The "High Risk, High Reward" Model in R&D: It is essential to direct existing resources beyond traditional platform modernization towards technologies that will change the character of warfare. R&D funding should focus on areas with high risk of failure but revolutionary potential, such as quantum computing, hypersonic systems, synthetic biology and advanced materials. This venture capital approach is what will transform Türkiye from a technology follower into a game-changer.

4. Vertical Integration in the Supply Chain and SME Strategy: The main contractor-focused growth model in the sector should be strengthened with a widespread industrial competence. A "Big-Small Collaboration Model" should be implemented where large companies act as system integrators and SMEs as specialized subsystem developers, ensuring predictable technology transfer and cash flow. This structure will not only increase export potential but is also key to establishing a sustainable production ecosystem without relying on a single firm.

5. AI Governance and National Data Sovereignty: The central role of artificial intelligence in defense and cybersecurity necessitates an institutional framework for the secure development of this technology. A "National AI Directorate" and an "AI Safety Institute" for ethical/safety oversight should be established for strategic coordination. Furthermore, the development of indigenous and national Large Language Models (LLMs) to reduce external dependence on the security of public and critical infrastructure data should be considered a strategic issue.

The contemporary Turkish defense industry has been transformed into a global technology player. However, carrying these achievements into the future depends on fostering a comprehensive innovation climate in Ankara as the brain of the sector going beyond mere production capabilities. In this strategic transformation, the Ankara Chamber of Industry will be a unifying force, bringing together all stakeholders—from universities and Technoparks to main contractors and SMEs—around the ideal of "making the capital a global deep technology center." The blend of public sector leadership, industrial dynamism and academia's depth will be the strongest guarantee of both national security and economic prosperity for Türkiye in the coming century all aligning with this shared vision.



CONCLUSION AND POLICY RECOMMENDATIONS



By 2025, the global economy is undergoing a period of "rebalancing" characterized by simultaneous low growth rates and high rates of technological transformation while geopolitical shifts shape trade and technology flows. The ASO-İLTEK 2025 results confirm that Türkiye is a rising player in this transformation process, particularly in innovation outputs and technological capabilities focused on the defense industry. However, the most striking reality revealed by the report is that the uneven distribution of technological advancement across the country is deepening and the gap between provinces is widening, particularly in terms of digital infrastructure and skilled human resources.

Spatial Segregation and Deepening Technological Hierarchy

The ASO-İLTEK Index 2025 results show that Türkiye's technology geography is consolidated in three key layers with decreasing transference:

- **Leaders (Ankara-Istanbul):** This core structure is completely isolated from other provinces, integrated into global networks and possesses significant capacity for research, digitalization and commercialization.
- **Emerging Industrial Centers (Kocaeli, Bursa, Eskişehir, İzmir, Kayseri):** This group has high production capacity but struggles to transition to digitalization and deep technology manufacturing and therefore shows signs of "losing ground" by 2025.
- **Followers Trapped in the Low-Tech Trap:** This refers to a broad geographical area at risk of being left out of technological transformation due to limiting factors, primarily by having insufficient digital infrastructure and human capital.

One of the most striking findings is that Eskişehir and Kocaeli, which were in the top (AA) category in 2024 dropped to a lower rating (BA) in 2025. Despite their strong industrial infrastructure, the widening gap between these provinces and the leading duo in digitalization and research capacity is a critical warning indicating that even industrial giants can lose ground in technological transformation. On the other hand, the increase in the number of provinces in the lowest (FF) category from 16 to 18 and the downgrading of 19 provinces to a lower category during the 2024-2025 transition, documents the structural difficulties experienced in spreading technological transformation to the grassroots level.

Sectoral Disruption and the Leverage Effect of the Defense Industry

The report's main theme this year, defense industry technologies has proven to be the area that generates the highest added value in line with Türkiye's strategic independence goals. The fact that the export value per kilogram in the defense and aerospace sector exceeds 65 USD, reaching 44 times the Turkish average, demonstrates the pioneering role of this sector in economic transformation. Conversely, contraction and job losses in labor-intensive traditional sectors (textiles, clothing) pose a structural risk for regions that fail to adapt to technological transformation.

This table reveals that Türkiye's technology policy needs to move away from a "one-size-fits-all" approach and evolve towards a spatially based regional policy approach that utilizes intervention tools specific to the potential of each province. In this context, the

following strategic roadmap is proposed for Türkiye to overcome the middle-income trap and achieve a technological leap in line with its 2030 vision:

1. Development of a National Dual-Use Strategy

The report's main theme, defense industry technologies has proven to be Türkiye's highest value-added generating sector. However, this success has largely remained limited to the Ankara-centered defense ecosystem and has reflected its expected extent in the civilian industry.

“ In order to systematically transfer the high technology produced in the defense industry to the civilian economy, Türkiye needs to create a binding national Dual-Use Strategy. ”

The first step to overcome this structural problem is to implement a formal National Dual-Use Strategy that Türkiye does not yet have. Without a strategy that breaks down the barriers between the military and civilian sectors, the transfer of gains from the defense industry to the civilian economy will remain limited. This strategy document should outline the legal, financial and institutional framework for transferring autonomous systems, advanced materials and battery technologies developed in the military field to the civilian automotive, healthcare and energy sectors. The goal is to transform the defense industry from a self-contained success story into a technological engine that transforms the national industry as a whole.

Once this strategy is designed, "Dual-Use Technology Centers" should be established to facilitate the transfer of artificial intelligence, autonomous systems, advanced materials and battery technologies developed for military platforms to the civilian industry. Special R&D and product development incentive mechanisms should be implemented (as in the examples of Biyovent and ASPİLSAN) to accelerate the integration of Ankara's defense-focused expertise into the automotive, healthcare and energy sectors in other provinces.

2. Region-Based Smart Specialization and Technology Interventions

The ASO-İLTEK results show that the needs of the provinces are not homogeneous. Therefore, technology policies should shift from "horizontal" incentives to "spatial" interventions:

“ Due to structural differences between provinces, technology policies should be redesigned with location-specific interventions targeting digital and green transformation in industrially intensive provinces, branding and commercialization in production-oriented Anatolian provinces and talent attraction in service and tourism provinces.”

"Digital and Green Transformation Shield" for Industrial Giants (Kocaeli, Bursa, Eskişehir): For these industrial giants, which are showing signs of relative decline compared to leading provinces in ASO-İLTEK 2025, the priority should be the digitalization of existing production lines and increasing productive capacity in the field of technology. In addition to these actions, the establishment of regional-scale Green Energy and Digital Transformation Centers should be considered to increase competitiveness in organized industrial zones which will reduce energy costs and ensure compliance with the EU Green Deal.

"Branding and Commercialization Support" for the Anatolian Tigers (Kayseri, Gaziantep): For these provinces that are strong in production and design registration but lag behind in export value per kilogram (compared to Ankara and Istanbul), mechanisms should be implemented to increase the effectiveness of technology transfer offices and support branding.

"Talent Attraction Centers" for Service and Tourism-Oriented Provinces (Antalya, Muğla): In these provinces with high quality of life but limited technology production, "Technology Free Zones" and co-working spaces should be encouraged to attract globally skilled tech professionals and digital nomads who work remotely.

3. Mobilization Focused on "Industrial Zones" in Digital Infrastructure

The report's findings show that digital infrastructure has become a key determinant of disparities in development between provinces. The low penetration of fiber optics in industrial areas outside of Kayseri, Istanbul and Ankara is limiting the growth of the digital economy.

“ To prevent the widening of inter-provincial disparities in the digital economy, instead of general infrastructure investments an industry-focused fiber optic and 5G initiative should be implemented targeting the second-tier provinces (Bursa, Izmir, Kocaeli, Manisa, Tekirdag) where industrial production is concentrated.”

To solve this problem, instead of a nationwide infrastructure investment, an "Industry-Focused Fiberization Initiative" should be launched, prioritizing the "Tier 2" provinces where industrial production is concentrated. The transition of Organized Industrial Zones and technoparks in these regions to 5G infrastructure should be accelerated and investments in regional data centers for the security and processing of industrial data should be included in strategic incentive programs.

4. "Deep Technology" Mission for Ankara and Istanbul

Ankara and Istanbul which occupy a leading position now have the potential to be game-changers not merely followers. The goal for these two provinces should be a shift from relatively easy fields like software and e-commerce to deeper technology areas such as biotechnology, quantum computing, semiconductors and artificial intelligence-based large language models (LLM).

“ To transform into globally leading technology hubs, Ankara and Istanbul must move beyond their current software and e-commerce focuses and initiate a strategic transformation centered on defense, finance and entrepreneurship.”

In this context, "Deep Technology Venture Capital Funds" should be established through public-private partnerships combining Ankara's defense industry expertise with Istanbul's financial and entrepreneurial strength. Furthermore, the development and public adoption of national artificial intelligence models for data sovereignty should be addressed as a "National Data Security" issue, spearheaded by these two provinces.

5. The Example of Kars and Iğdır: Correctly Understanding Regional Potential

The surprising divergence between Kars and Iğdır in the Sectoral Structure sub-index of the report demonstrates that technological development cannot be measured solely by "factory chimneys." The momentum these provinces have gained through the services sector and cross-border trade could serve as a model for other provinces in Eastern Anatolia. Instead of heavy industry investments in these regions, supporting micro-local development models based on logistics, border trade integration and digital services would be a more realistic and results-oriented strategy for reducing regional inequality.

“ Instead of industry-focused development strategies in Eastern Anatolia, micro-local development models based on logistics, border trade and digital activities should be developed. ”

In conclusion, ASO-İLTEK 2025 demonstrates that Türkiye is at a critical juncture in technological transformation. On one hand, there is a defense industry producing at global standards and a vibrant entrepreneurial ecosystem; on the other hand, there are traditional industrial zones struggling with digitalization and productivity. The main objective of future policies should be to eliminate this dual structure and integrate the technological capacity accumulated in Ankara and Istanbul with the production power of Anatolia through spatially focused smart policies.

“ The advanced technology capacity accumulated in the centers of Türkiye needs to be integrated into Anatolia's production ecosystem through site-specific smart policies. ”



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APPENDICES

APPENDIX 1. RESEARCH METHODOLOGY AND DATA

The ASO Technological Development Index of Provinces (ASO-İLTEK) 2025 study was prepared adhering to the methodological framework established in the first report published in 2024. The study measures the level of technological development and readiness for digital transformation of all 81 provinces in Türkiye through 5 main components and 37 variables. The data set used in the 2025 calculations has been updated with the most recent data (2023-2025) published by the relevant institutions.

Data Set and Resources

The variables, data sources, reference years, and units used in calculating the index are presented in the table below:

	Data Source	Year	Unit
Sectoral Structure Variables			
Share of high-tech manufacturing and services in the total number of enterprises	TÜİK	2023	Per thousand
The share of employees working in high-tech manufacturing and high-tech knowledge- intensive service provision among the compulsory insured under 4/1-a	SGK, TÜİK	2024	Per thousand
Research and Innovation Capacity Variables			
Number of R&D Centers per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2024	Number
Number of Technology Development Zones per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2024	Number
Number of Design Centers per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2024	Number
Number of publications in universities	ULAKBİM	2024	Number
Number of university projects over the last 5 years	ULAKBİM	2023	Number
Number of students in technology-related fields per 1,000 enterprises	YÖK, TÜİK	2024	Number
Number of academicians in technology-related fields per 1,000 enterprises	YÖK, TÜİK	2024	Number
Number of companies receiving industrial R&D support per thousand manufacturing enterprises	TÜBİTAK, TÜİK	2024	Number
Amount of industrial R&D support per thousand enterprises	TÜBİTAK, TÜİK	2024	TRY
Number of companies receiving industrial entrepreneurship support per thousand manufacturing enterprises	TÜBİTAK, TÜİK	2024	Number
Amount of industrial entrepreneurship support per thousand enterprises	TÜBİTAK, TÜİK	2024	TRY
Digital Infrastructure Variables			
Broadband subscribers per hundred people	BTK, TÜİK	2024	Number
Share of fibre broadband subscribers	BTK, TÜİK	2024	Percentage
Number of mobile broadband subscribers per hundred people	BTK, TÜİK	2024	Number
Number of 3G and 4.5G connected mobile phones per hundred people	BTK, TÜİK	2024	Number
Technology Output Variables			
Number of patent registrations per thousand people	Türk Patent, TÜİK	2024	Number
Number of utility model registrations per thousand people	Türk Patent, TÜİK	2024	Number
Number of design registrations per thousand people	Türk Patent, TÜİK	2024	Number
Export of high-tech per enterprise in the manufacturing sector	TÜİK	2024	USD

Quality of Life and Workforce Attractiveness Variables			
Student-Friendly University City Index	ÜniAR	2025	Score
Average net migration rate	TÜİK	2022-2024	Per thousand
Number of cinema seats per hundred people	TÜİK	2024	Number
Number of theatre seats per hundred people	TÜİK	2024	Number
Average wage in the private sector (PPP-adjusted)	SGK, TÜİK	2024	TRY
Male- Female average wage ratio	SGK	2024	Percentage
Average wages of women (PPP-adjusted)	SGK, TÜİK	2024	TRY
Unemployment rate	TÜİK	2024	Percentage
Employment rate	TÜİK	2024	Percentage
Shopping and trade area per thousand inhabitants	Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, TÜİK	2025	m²
Leisure, culture and sports facilities per thousand inhabitants	Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, TÜİK	2025	m²
Number of social hubs per 100 persons over 18 years of age	Republic of Türkiye Ministry of Agriculture and Forestry, TÜİK	2025	Number
Number of specialised physicians per hundred inhabitants	TÜİK	2023	Number
Number of students per classroom in primary education	TÜİK	2024	Number
Number of students per teacher in primary school	TÜİK	2024	Number
Net preschool enrollment rate for 3-5 age group	TÜİK	2024	Percentage

Statistical Method and Calculation Steps

The index was constructed using three fundamental statistical steps: data standardization, weighting, and clustering.

Data Standardization (Z-Score and Min-Max)

In order to make variables with different units (quantity, TL, rate, etc.) comparable, a Z-score transformation was applied in the first stage. This method of expressing the deviation of each observation from the mean in terms of standard deviation is calculated using the following formula: The obtained Z-scores were rescaled using the min-max method to ensure that the index scores took values between 0 and 1.

$$Z = \frac{x - \text{Mean}}{\text{Standard Deviation}}$$

For variables with inverse metrics (where a low value is positive), such as the unemployment rate, the inverse scaling formula was used.

$$X_{\text{rescaled}} = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Weighting: Principal Components Analysis (PCA)

Principal Components Analysis (PCA) was used to determine the weights of the variables and sub-indices based on the variance in the data set rather than subjective judgments.

- The PCA method minimizes the multicollinearity problem between variables and derives the components that best summarize the information in the dataset.
- For each sub-index, principal components with eigenvalues greater than 1 were considered and weighted scores were generated based on the proportions of variance explained by these components.
- The final ASO-ILTEK score is the first principal component score obtained by combining the 5 sub-indices using the PCA method.

Classification and Rating Method

In classifying provinces according to their technological development levels (from AA to FF), instead of a single method, a synthesis of three different clustering techniques was used:

- 1. Equal Intervals:** Divide the score interval into equal parts.
- 2. Jenks Natural Breaks:** Minimizes within-class variance by identifying natural groupings and break points within the data.
- 3. K-Means:** Divides provinces into homogeneous groups based on their similarities.

The final letter grade (rank) for each province was determined by calculating the average of the cluster values obtained according to these three methods. This approach has increased the accuracy of the ranking and balanced the potential bias effect of outliers on the classification.



APPENDIX 2. RANKING OF PROVINCES IN 2025 BASED ON VARIABLES USED IN ASO-İLTEK

Variable	Adana	Adıyaman	Afyon	Ağrı	Aksaray	Amasya	Ankara	Antalya
High-tech share in startups	9	75	71	60	70	51	2	7
High-tech share in employment	21	38	63	14	59	62	1	26
R&D Centers	29	36	55	68	33	40	8	35
TDZ	57	66	35	71	19	64	33	56
Design Center	13	43	69	38	70	39	8	28
Publications	7	52	27	73	48	62	2	10
Projects of Universities	12	51	35	62	69	68	2	7
Students in technology departments	40	68	28	74	30	67	6	66
Academics in technology departments	52	70	38	75	48	46	14	72
Companies receiving industrial support	19	43	46	78	66	64	1	24
Company receiving entrepreneurship support	35	68	37	77	26	61	2	22
Amount of industrial support	22	5	53	79	61	65	1	30
Amount of entrepreneurship support	32	50	24	77	16	49	5	28
Broadband subscriber	33	76	52	81	41	38	2	4
Fiber subscriber	39	27	38	37	36	72	5	17
Mobile broadband	4	2	26	22	10	6	5	15
3G-4.5G phone	7	5	23	47	14	16	2	9
Patent	34	75	62	77	35	40	1	36
Utility model	29	63	53	78	49	74	6	30
Design	41	12	49	77	42	22	8	25
H-T Exports	16	12	47	36	50	75	2	7
Student-friendly city	15	33	58	66	64	46	4	23
Net migration rate	57	74	53	81	37	29	22	15
Cinema seats	40	56	43	63	73	48	3	19
Theater seats	48	80	78	67	73	52	25	9
Average Wage	34	57	53	43	22	62	2	31
Male-Female wage ratio	46	8	32	22	58	41	53	10
Average Wage (female)	55	59	67	15	43	75	2	28

Variable	Adana	Adıyaman	Afyon	Ağrı	Aksaray	Amasya	Ankara	Antalya
Unemployment	71	68	14	79	30	27	58	12
Employment	53	66	19	68	50	32	37	4
Shopping and commercial area	8	74	33	15	7	63	1	34
Entertainment, culture, and sports venue	23	70	32	48	20	46	10	18
Establishments with alcohol	20	72	55	76	54	34	23	4
Specialist Physician	11	71	46	77	64	56	1	5
Students per Classroom	75	49	13	13	27	7	54	60
Students per Teacher	67	54	8	54	44	8	44	44
Preschool Education	64	63	55	70	69	27	41	19

Variable	Ardahan	Artvin	Aydın	Balıkesir	Bartın	Batman	Bayburt	Bilecik
High-tech share in startups	81	66	46	36	49	24	50	40
High-tech share in employment	64	77	58	43	76	40	53	67
R&D Centers	78	76	26	19	67	42	74	4
TDZ	59	77	51	49	73	7	58	60
Design Center	33	31	19	54	37	52	79	7
Publications	80	68	23	29	61	77	72	66
Projects of Universities	78	49	16	48	41	52	71	38
Students in technology departments	70	77	64	39	4	63	43	3
Academics in technology departments	69	77	71	58	9	42	26	6
Companies receiving industrial support	60	67	39	45	79	52	70	23
Company receiving entrepreneurship support	57	59	34	69	45	48	56	66
Amount of industrial support	59	78	31	42	74	48	71	27
Amount of entrepreneurship support	62	58	36	73	59	76	81	54
Broadband subscriber	59	39	10	15	34	73	51	24
Fiber abone	62	59	41	66	52	18	55	25

Variable	Ardahan	Artvin	Aydın	Balıkesir	Bartın	Batman	Bayburt	Bilecik
Mobile broadband	7	9	37	23	45	71	43	34
3G-4.5G phone	13	10	37	32	39	75	51	48
Patent	80	48	30	46	74	57	76	11
Utility model	79	80	31	39	52	57	47	24
Design	51	43	53	62	74	28	18	68
H-T Exports	77	57	43	34	74	32	78	11
Student-friendly city	45	35	18	4	38	64	79	42
Net migration rate	75	44	21	18	13	55	69	20
Cinema seats	80	62	37	41	55	39	24	77
Theater seats	2	6	50	14	18	74	22	55
Average Wage	32	65	51	27	56	74	75	9
Male-Female wage ratio	20	38	33	59	76	54	30	74
Average Wage (female)	4	60	72	39	79	73	35	29
Unemployment	5	48	61	8	28	77	37	43
Employment	1	16	43	26	7	75	30	18
Shopping and commercial area	66	44	36	18	24	3	69	17
Entertainment, culture, and sports venue	55	27	25	13	16	30	44	24
Establishments with alcohol	29	11	6	7	13	77	68	39
Specialist Physician	55	54	18	28	63	66	50	51
Students per Classroom	1	7	49	38	5	65	2	38
Students per Teacher	8	8	8	8	1	67	1	54
Preschool Education	46	2	30	8	35	75	39	15

Variable	Bingöl	Bitlis	Bolu	Burdur	Bursa	Çanakkale	Çankırı	Çorum
High-tech share in startups	80	56	20	79	6	39	67	37
High-tech share in employment	70	78	20	60	28	32	27	45
R&D Centers	58	59	14	43	3	44	24	53
TDZ	75	72	6	10	55	34	2	27
Design Center	77	65	30	40	3	22	60	62
Publications	60	75	31	44	8	24	59	54
Projects of Universities	79	55	19	42	9	18	36	57

Variable	Bingöl	Bitlis	Bolu	Burdur	Bursa	Çanakkale	Çankırı	Çorum
Students in technology departments	27	55	9	16	47	35	14	53
Academics in technology departments	17	51	15	25	60	45	8	80
Companies receiving industrial support	15	76	50	51	9	21	68	58
Company receiving entrepreneurship support	51	12	11	79	28	16	64	43
Amount of industrial support	38	81	23	39	7	24	64	54
Amount of entrepreneurship support	78	9	34	38	18	22	61	46
Broadband subscriber	69	75	28	35	13	11	60	47
Fiber subscriber	33	3	67	70	42	60	51	47
Mobile broadband	67	74	42	36	14	25	49	27
3G-4.5G phone	69	79	41	42	15	38	4	28
Patent	68	69	26	13	5	18	81	37
Utility model	60	66	34	9	1	16	4	27
Design	56	73	48	70	2	67	69	65
H-T Exports	70	80	31	71	19	48	21	23
Student-friendly city	79	67	11	51	7	4	68	55
Net migration rate	65	70	28	36	33	7	10	52
Cinema seats	42	78	14	36	22	52	60	29
Theater seats	29	40	12	35	36	5	7	69
Average Wage	52	77	21	63	15	25	3	46
Male-Female wage ratio	43	11	57	40	66	70	71	55
Average Wage (female)	56	58	27	74	23	46	6	64
Unemployment	26	72	19	2	57	21	3	15
Employment	71	61	8	17	28	34	48	54
Shopping and commercial area	32	22	57	41	5	38	46	68
Entertainment, culture, and sports venue	58	43	61	39	8	11	52	69
Establishments with alcohol	71	69	31	30	25	2	73	67
Specialist Physician	75	74	12	62	21	16	73	60
Students per Classroom	54	7	38	27	74	44	13	27
Students per Teacher	54	44	25	1	67	25	54	25
Preschool Education	74	68	16	7	57	6	32	33

Variable	Denizli	Diyarbakır	Düzce	Edirne	Elazığ	Erzincan	Erzurum	Eskişehir
High-tech share in startups	17	15	11	18	32	52	31	5
High-tech share in employment	25	36	11	17	23	49	33	7
R&D Centers	20	41	5	69	52	30	79	6
TDZ	48	41	16	22	26	67	23	39
Design Center	2	29	9	48	72	42	50	15
Publications	19	22	37	32	13	46	5	6
Projects of Universities	37	44	46	60	11	50	20	4
Students in technology departments	33	57	8	18	7	60	5	1
Academics in technology departments	55	65	19	35	3	16	1	4
Companies receiving industrial support	33	41	14	35	4	62	55	3
Company receiving entrepreneurship support	24	42	73	21	29	62	25	3
Amount of industrial support	21	47	37	45	6	76	57	3
Amount of entrepreneurship support	13	51	57	33	35	60	20	7
Broadband subscriber	17	71	20	12	55	40	58	5
Fiber subscriber	79	2	57	68	7	74	76	34
Mobile broadband	19	76	55	18	51	60	58	21
3G-4.5G phone	18	43	57	12	35	62	56	19
Patent	31	58	33	43	8	54	14	7
Utility model	13	77	25	48	36	71	40	8
Design	9	55	7	80	32	79	21	19
H-T Exports	26	15	58	42	52	54	38	1
Student-friendly city	7	55	37	13	62	60	39	1
Net migration rate	40	67	23	19	35	56	72	12
Cinema seats	12	30	28	1	54	44	2	7
Theater seats	19	68	57	13	59	10	47	23
Average Wage	58	67	26	50	37	38	39	6
Male-Female wage ratio	39	17	64	49	47	67	24	75
Average Wage (female)	78	61	53	63	33	45	11	12
Unemployment	20	63	34	31	6	35	9	42
Employment	10	76	5	11	70	57	36	39
Shopping and commercial area	48	64	6	45	40	58	59	10

Variable	Denizli	Diyarbakır	Düzce	Edirne	Elazığ	Erzincan	Erzurum	Eskişehir
Entertainment, culture, and sports venue	17	74	6	34	68	35	31	7
Establishments with alcohol	22	57	32	5	53	41	74	21
Specialist Physician	14	45	33	7	9	31	20	6
Students per Classroom	44	75	38	27	49	13	13	64
Students per Teacher	44	75	25	8	54	25	44	25
Preschool Education	21	79	9	10	52	1	71	21

Variable	Gaziantep	Giresun	Gümüşhane	Hakkari	Hatay	İğdır	Isparta	İstanbul
High-tech share in startups	34	73	47	8	54	35	14	1
High-tech share in employment	39	73	68	79	61	6	34	2
R&D Centers	31	48	62	75	50	77	51	10
TDZ	40	18	63	79	32	1	21	53
Design Center	25	57	51	36	24	47	71	5
Publications	25	51	57	81	33	74	11	1
Projects of Universities	17	67	80	75	23	64	14	1
Students in technology departments	52	48	20	78	58	25	44	21
Academics in technology departments	61	59	12	78	67	23	7	31
Companies receiving industrial support	37	53	80	61	48	26	8	6
Company receiving entrepreneurship support	36	41	44	63	33	38	9	14
Amount of industrial support	16	56	68	67	52	50	14	4
Amount of entrepreneurship support	26	53	80	70	25	47	12	11
Broadband subscriber	53	45	67	78	63	68	26	1
Fiber subscriber	21	73	63	14	80	20	45	9
Mobile broadband	30	65	79	63	12	69	24	1
3G-4.5G phone	29	60	73	67	20	71	25	1
Patent	23	60	67	71	39	70	22	3
Utility model	37	41	62	72	61	20	7	3
Design	6	47	59	81	36	57	15	3

Variable	Gaziantep	Giresun	Gümüşhane	Hakkari	Hatay	Iğdır	Isparta	İstanbul
H-T Exports	5	56	76	72	24	35	28	3
Student-friendly city	31	19	68	81	51	75	31	16
Net migration rate	54	24	46	68	79	63	42	61
Cinema seats	53	61	75	81	72	79	21	5
Theater seats	46	62	4	30	76	72	42	26
Average Wage	28	81	66	42	18	54	72	5
Male-Female wage ratio	9	14	18	1	48	6	34	12
Average Wage (female)	21	80	41	7	10	20	70	3
Unemployment	62	11	65	81	75	70	25	53
Employment	60	20	65	81	63	29	22	15
Shopping and commercial area	50	30	14	27	52	77	39	16
Entertainment, culture, and sports venue	71	66	19	50	72	53	29	22
Establishments with alcohol	63	27	64	48	17	51	36	18
Specialist Physician	34	43	69	59	49	80	4	3
Students per Classroom	81	13	2	54	65	13	13	78
Students per Teacher	80	25	8	54	65	25	1	77
Preschool Education	76	4	40	66	59	28	11	54

Variable	İzmir	K.maraş	Karabük	Karaman	Kars	Kastamonu	Kayseri	Kırıkkale
High-tech share in startups	4	41	30	61	74	62	10	43
High-tech share in employment	12	31	48	80	8	50	19	10
R&D Centers	11	13	39	23	72	46	18	38
TDZ	50	38	4	5	62	13	36	3
Design Center	11	23	12	41	58	80	17	76
Publications	3	28	53	58	40	47	12	36
Projects of Universities	3	28	29	27	73	72	6	45
High-tech share in startups	26	65	2	41	29	49	17	80
High-tech share in employment	39	64	81	27	21	62	32	11
Companies receiving industrial support	7	11	31	42	72	40	27	13

Variable	İzmir	K.maraş	Karabük	Karaman	Kars	Kastamonu	Kayseri	Kırıkkale
Company receiving entrepreneurship support	10	72	13	18	78	80	4	58
Amount of industrial support	9	10	25	41	62	49	17	18
Amount of entrepreneurship support	8	44	10	31	75	55	1	72
Broadband subscriber	3	64	14	30	66	42	18	46
Fiber subscriber	15	8	13	78	30	43	4	29
Mobile broadband	8	39	47	46	66	57	41	44
3G-4.5G phone	8	45	54	46	68	63	31	59
Patent	9	32	16	27	73	42	4	78
Utility model	11	35	15	14	50	21	5	59
Design	13	37	50	10	76	27	1	78
Companies receiving industrial support	6	41	59	66	79	65	17	37
Company receiving entrepreneurship support	21	46	39	72	72	55	28	58
Amount of industrial support	30	73	45	38	76	9	47	17
Amount of entrepreneurship support	15	65	8	64	76	10	27	9
Broadband subscriber	21	81	17	24	20	31	45	79
Fiber subscriber	16	33	11	19	59	55	30	12
Mobile broadband	65	19	79	37	27	61	44	80
3G-4.5G phone	17	31	51	19	14	71	42	16
Patent	66	74	59	36	29	1	55	69
Utility model	35	62	64	31	6	3	59	74
Design	13	26	60	47	11	35	51	2
Entertainment, culture, and sports venue	15	45	57	51	14	40	28	12
Establishments with alcohol	10	66	33	46	38	40	65	56
Specialist Physician	2	52	36	39	58	57	22	30
Students per Classroom	71	72	38	13	2	13	64	27
Students per Teacher	44	67	25	8	8	25	54	25
Preschool Education	42	78	17	44	60	18	48	38

Variable	Kırklareli	Kırşehir	Kilis	Kocaeli	Konya	Kütahya	Malatya	Manisa
High-tech share in startups	38	76	58	3	33	44	22	48
High-tech share in employment	9	74	18	4	22	46	44	5
R&D Centers	15	70	80	1	21	12	25	7
TDZ	15	65	78	17	45	29	31	52
Design Center	18	34	75	4	27	6	21	10
Publications	64	45	71	20	4	38	14	26
Projects of Universities	66	59	53	8	10	34	21	33
Students in technology departments	32	13	31	19	24	15	23	75
Academics in technology departments	50	13	33	28	34	30	24	57
Companies receiving industrial support	49	59	71	2	29	17	32	30
Company receiving entrepreneurship support	47	53	60	7	30	8	23	32
Amount of industrial support	58	77	73	2	12	19	32	20
Amount of entrepreneurship support	40	67	41	3	23	6	17	29
Broadband subscriber	8	36	44	19	25	37	65	43
Fiber subscriber	28	58	50	32	75	54	6	65
Mobile broadband	80	52	3	16	38	28	13	53
3G-4.5G phone	74	55	3	6	21	40	26	52
Patent	50	55	66	6	15	19	38	12
Utility model	32	46	44	10	2	19	54	12
Design	60	26	39	30	4	17	40	29
H-T Exports	61	64	33	4	20	53	60	9
Student-friendly city	23	19	76	21	26	26	39	3
Net migration rate	5	27	8	14	41	62	80	39
Cinema seats	32	51	59	23	33	34	57	38
Theater seats	33	51	28	32	34	3	44	65
Average Wage	13	7	44	1	29	20	41	10
Male-Female wage ratio	77	78	4	72	45	56	31	68
Average Wage (female)	32	40	9	1	25	13	44	18
Unemployment	10	56	76	50	39	23	7	16
Employment	21	69	56	9	45	41	42	13
Shopping and commercial area	9	65	62	25	55	43	29	71

Variable	Kırklareli	Kırşehir	Kilis	Kocaeli	Konya	Kütahya	Malatya	Manisa
Entertainment, culture, and sports venue	5	67	79	3	36	41	33	54
Establishments with alcohol	8	44	79	45	60	59	70	24
Specialist Physician	29	44	35	23	19	47	15	24
Students per Classroom	27	27	75	64	60	13	54	54
Students per Teacher	25	8	77	65	65	8	44	25
Preschool Education	5	23	72	20	61	29	56	53

Variable	Mardin	Mersin	Muğla	Muş	Nevşehir	Niğde	Ordu	Osmaniye
High-tech share in startups	53	21	28	68	57	29	59	72
High-tech share in employment	66	41	55	75	51	56	57	69
R&D Centers	60	32	57	63	47	27	54	37
TDZ	69	42	54	80	14	9	70	20
Design Center	74	26	67	55	44	56	64	73
Publications	69	21	35	65	55	41	50	67
Projects of Universities	77	22	24	76	70	25	63	74
Students in technology departments	79	56	61	62	34	38	76	72
Academics in technology departments	79	66	68	47	54	10	74	36
Companies receiving industrial support	73	36	47	81	10	5	65	54
Company receiving entrepreneurship support	52	27	49	39	76	1	74	50
Amount of industrial support	63	43	34	60	29	33	75	51
Amount of entrepreneurship support	48	30	71	64	65	2	63	52
Broadband subscriber	70	22	7	80	23	50	57	62
Fiber subscriber	16	35	71	40	61	11	48	53
Mobile broadband	75	70	11	78	56	61	40	48
3G-4.5G phone	77	58	17	80	50	65	44	61
Patent	64	41	56	72	24	20	63	49
Utility model	65	26	22	76	28	18	38	58
Design	58	20	54	71	44	23	24	33

Variable	Mardin	Mersin	Muğla	Muş	Nevşehir	Niğde	Ordu	Osmaniye
H-T Exports	8	27	51	67	29	63	55	68
Student-friendly city	54	2	7	76	43	51	17	68
Net migration rate	58	34	3	78	16	31	32	60
Cinema seats	70	46	25	74	6	50	58	68
Theater seats	43	38	11	8	16	64	49	66
Average Wage	79	17	35	61	60	45	80	24
Male-Female wage ratio	2	63	21	16	7	29	28	62
Average Wage (female)	69	30	48	34	57	47	81	37
Unemployment	73	22	41	78	18	45	32	67
Employment	79	46	25	77	38	47	23	67
Shopping and commercial area	21	54	12	76	37	56	28	70
Entertainment, culture, and sports venue	42	49	1	80	2	56	21	77
Establishments with alcohol	58	12	1	80	3	43	28	49
Specialist Physician	72	26	13	79	53	68	42	70
Students per Classroom	65	72	44	27	7	13	44	64
Students per Teacher	75	54	8	54	8	25	25	44
Preschool Education	81	51	12	73	14	58	36	49

Variable	Rize	Sakarya	Samsun	Siirt	Sinop	Sivas	Şanlıurfa	Şırnak
High-tech share in startups	27	12	23	65	77	16	63	64
High-tech share in employment	30	16	24	81	71	13	37	65
R&D Centers	71	9	34	81	65	22	56	61
TDZ	11	43	47	68	74	24	46	61
Design Center	35	14	45	32	46	61	68	49
Publications	42	16	9	63	70	18	34	79
Projects of Universities	32	13	15	43	56	31	47	65
Students in technology departments	45	12	46	51	71	11	69	73
Academics in technology departments	29	18	44	22	40	20	73	76
Companies receiving industrial support	16	12	18	75	63	22	44	69

Variable	Rize	Sakarya	Samsun	Siirt	Sinop	Sivas	Şanlıurfa	Şırnak
Company receiving entrepreneurship support	17	19	5	75	55	31	15	46
Amount of industrial support	13	8	26	72	69	28	40	66
Amount of entrepreneurship support	14	19	4	45	66	21	27	74
Broadband subscriber	27	29	32	72	49	48	79	74
Fiber subscriber	49	56	23	12	77	26	24	31
Mobile broadband	31	35	29	72	64	50	77	81
3G-4.5G phone	34	24	27	76	66	33	78	81
Patent	10	2	28	47	53	45	65	79
Utility model	64	17	45	55	70	51	67	73
Design	46	5	16	63	38	35	64	75
H-T Exports	44	10	22	39	49	13	14	30
Student-friendly city	49	33	7	60	25	28	49	76
Net migration rate	51	11	25	71	4	49	66	64
Cinema seats	4	16	45	49	18	26	67	69
Theater seats	15	54	71	60	1	37	63	77
Average Wage	68	8	48	49	76	36	69	71
Male-Female wage ratio	26	73	36	25	35	60	13	3
Average Wage (female)	65	22	62	49	76	36	54	24
Unemployment	47	49	33	64	13	54	46	44
Employment	14	12	44	80	52	51	72	73
Shopping and commercial area	19	42	61	79	72	49	80	81
Entertainment, culture, and sports venue	47	26	59	81	37	63	78	75
Establishments with alcohol	42	35	37	78	16	61	75	81
Specialist Physician	17	38	8	76	67	37	78	81
Students per Classroom	7	54	27	49	27	13	80	60
Students per Teacher	25	44	8	67	25	25	81	77
Preschool Education	24	26	31	65	13	62	80	77

Variable	Tekirdağ	Tokat	Trabzon	Tunceli	Uşak	Van	Yalova	Yozgat	Zonguldak
High-tech share in startups	26	42	25	78	55	19	13	69	45
High-tech share in employment	3	29	15	72	35	42	52	54	47
R&D Centers	2	73	49	66	17	64	16	45	28
TDZ	44	25	37	81	76	30	8	12	28
Design Center	1	81	78	53	63	59	16	66	20
Publications	43	30	15	78	56	17	76	49	39
Projects of Universities	30	40	5	81	58	26	39	61	54
Students in technology departments	59	37	10	42	81	54	22	50	36
Academics in technology departments	63	43	5	2	56	49	41	53	37
Companies receiving industrial support	25	38	20	74	57	34	28	77	56
Company receiving entrepreneurship support	67	65	6	70	71	54	40	20	81
Amount of industrial support	11	46	15	80	44	36	35	70	55
Amount of entrepreneurship support	39	69	15	43	42	68	56	37	79
Broadband subscriber	9	61	31	56	16	77	6	54	21
Fiber subscriber	19	69	10	44	22	1	64	46	81
Mobile broadband	54	59	20	73	32	68	62	33	17
3G-4.5G phone	53	64	11	70	30	72	49	36	22
Patent	21	51	29	17	59	61	44	52	25
Utility model	23	42	33	81	75	69	43	68	56
Design	34	11	14	45	52	72	31	61	66
H-T Exports	18	69	25	81	40	73	46	62	45
Student-friendly city	13	63	11	43	71	46	35	74	28
Net migration rate	2	26	48	6	43	77	1	59	50
Cinema seats	31	35	17	71	47	66	13	20	11
Theater seats	39	56	27	58	41	75	70	61	53
Average Wage	4	78	64	73	47	70	23	40	14
Male-Female wage ratio	69	23	15	5	50	52	42	51	81
Average Wage (female)	5	77	66	8	68	50	26	38	52
Unemployment	24	17	51	4	38	80	52	40	60
Employment	2	33	24	58	27	78	55	40	49
Shopping and commercial area	4	78	23	67	31	75	53	73	20

Variable	Tekirdağ	Tokat	Trabzon	Tunceli	Uşak	Van	Yalova	Yozgat	Zonguldak
Entertainment, culture, and sports venue	4	76	9	65	73	60	62	64	38
Establishments with alcohol	14	47	50	9	26	52	15	62	19
Specialist Physician	40	41	10	48	25	61	27	65	32
Students per Classroom	78	27	38	7	44	60	49	5	13
Students per Teacher	67	8	25	1	1	67	54	8	1
Preschool Education	47	45	37	3	34	67	25	50	43



APPENDIX 3. ASO-ILTEK GENERAL INDEX PERFORMANCE OF PROVINCES IN THE PERIOD 2023-2025

Province	2023			2024			2025		
	Rating	Score	Ranking	Rating	Score	Ranking	Rating	Score	Ranking
Ankara	AA	1,000	1	AA	1,000	1	AA	1,000	1
İstanbul	AA	0,964	2	AA	0,940	2	AA	0,962	2
Eskişehir	BA	0,683	3	AA	0,800	3	BA	0,675	3
Kocaeli	BA	0,673	4	AA	0,700	4	BA	0,666	4
İzmir	BB	0,584	5	BB	0,530	5	BB	0,539	5
Kayseri	CB	0,425	8	BB	0,440	7	BB	0,526	6
Bursa	BB	0,531	6	BB	0,510	6	BB	0,525	7
Sakarya	CB	0,462	7	BB	0,410	8	CB	0,401	8
Tekirdağ	CB	0,418	9	CB	0,390	9	CC	0,370	9
Antalya	CC	0,367	12	CC	0,340	13	CC	0,348	10
Trabzon	CC	0,351	16	CC	0,330	15	CC	0,348	11
Isparta	CC	0,331	19	CC	0,320	16	CC	0,348	12
Denizli	CC	0,362	14	CC	0,330	14	CC	0,333	13
Konya	CC	0,355	15	CC	0,310	18	CC	0,331	14
Manisa	CC	0,371	11	CB	0,360	12	CC	0,321	15
Düzce	CC	0,386	10	CB	0,370	11	CC	0,320	16
Kütahya	DC	0,288	29	CC	0,280	24	CC	0,305	18
Samsun	CC	0,299	26	CC	0,270	28	CC	0,305	17
Adana	CC	0,317	23	CC	0,280	21	CC	0,301	19
Elazığ	DC	0,260	38	CC	0,280	23	CC	0,296	20
Karabük	CC	0,337	18	CB	0,380	10	CC	0,290	21
Niğde	DD	0,198	56	DC	0,200	45	CC	0,285	22
Muğla	CC	0,329	20	CC	0,280	22	CC	0,283	23
Çanakkale	CC	0,314	24	CC	0,290	20	CC	0,282	24
Edirne	CC	0,366	13	CC	0,310	17	CC	0,268	25
Bolu	DC	0,282	30	CC	0,310	19	CC	0,264	26
Rize	CC	0,296	27	CC	0,270	27	CC	0,263	27
Bilecik	CC	0,327	21	CC	0,270	25	CC	0,261	28
Malatya	DC	0,267	37	CC	0,260	30	CC	0,259	29
Çankırı	DC	0,269	36	CC	0,260	29	CC	0,256	30
Sivas	CC	0,348	17	CC	0,240	33	CC	0,250	31

Province	2023			2024			2025		
	Rating	Score	Ranking	Rating	Score	Ranking	Rating	Score	Ranking
Adıyaman	CC	0,294	28	DC	0,210	43	DC	0,240	32
Gaziantep	DC	0,248	42	DC	0,220	39	DC	0,235	33
Balıkesir	DC	0,279	31	CC	0,250	32	DC	0,226	34
Kilis	DD	0,220	48	DC	0,210	42	DC	0,223	35
Kırklareli	CC	0,325	22	CC	0,230	35	DC	0,222	36
Erzurum	DD	0,215	50	DC	0,220	38	DC	0,220	37
Aydın	DC	0,275	34	DC	0,210	41	DC	0,219	38
Karaman	CC	0,302	25	CC	0,230	36	DC	0,211	39
Nevşehir	DC	0,235	45	CC	0,230	37	DC	0,211	40
Yalova	DC	0,276	33	CC	0,270	26	DC	0,210	41
İğdır	FF	0,124	72	DD	0,120	65	DC	0,210	42
Mersin	DC	0,243	43	DD	0,200	46	DC	0,208	43
Kırıkkale	DC	0,252	40	DD	0,190	50	DC	0,207	44
Burdur	DC	0,271	35	CC	0,230	34	DC	0,206	45
Aksaray	DC	0,232	46	DD	0,180	52	DD	0,197	46
Kahramanmaraş	FF	0,170	62	DD	0,160	55	DD	0,196	47
Amasya	DC	0,250	41	DD	0,190	48	DD	0,192	48
Uşak	DC	0,236	44	DD	0,180	51	DD	0,187	50
Artvin	DC	0,254	39	DD	0,160	54	DD	0,187	49
Zonguldak	DC	0,279	32	CC	0,250	31	DD	0,186	51
Çorum	DD	0,213	52	DD	0,150	57	DD	0,184	52
Kastamonu	DD	0,223	47	DD	0,190	47	DD	0,183	53
Kars	FF	0,165	64	DD	0,170	53	DD	0,180	54
Afyon	DD	0,209	54	DD	0,160	56	DD	0,174	55
Ardahan	DD	0,215	51	DD	0,190	49	DD	0,171	56
Bartın	DD	0,216	49	DC	0,210	40	DD	0,168	57
Tokat	DD	0,207	55	DC	0,200	44	DD	0,167	58
Bayburt	FF	0,155	66	DD	0,150	59	DD	0,162	59
Ordu	DD	0,188	59	DD	0,130	63	DD	0,155	60
Yozgat	DD	0,190	58	DD	0,140	60	DD	0,153	61
Hatay	DD	0,191	57	DD	0,150	58	DD	0,146	62
Diyarbakır	FF	0,135	69	FF	0,100	67	DD	0,145	63
Kırşehir	DD	0,184	61	DD	0,140	62	FF	0,140	64
Erzincan	DD	0,187	60	DD	0,140	61	FF	0,133	65
Sinop	FF	0,168	63	DD	0,120	64	FF	0,128	66



Province	2023			2024			2025		
	Rating	Score	Ranking	Rating	Score	Ranking	Rating	Score	Ranking
Tunceli	FF	0,142	68	FF	0,110	66	FF	0,125	67
Giresun	FF	0,157	65	FF	0,100	69	FF	0,123	68
Van	FF	0,110	74	FF	0,080	74	FF	0,119	69
Ağrı	FF	0,149	67	FF	0,100	68	FF	0,113	70
Osmaniye	FF	0,125	71	FF	0,080	72	FF	0,107	71
Bitlis	FF	0,083	76	FF	0,040	76	FF	0,101	72
Batman	FF	0,125	70	FF	0,090	71	FF	0,099	73
Hakkari	FF	0,069	78	FF	0,030	77	FF	0,096	74
Bingöl	FF	0,102	75	FF	0,080	73	FF	0,091	75
Gümüşhane	FF	0,111	73	FF	0,050	75	FF	0,084	76
Siirt	FF	0,066	79	FF	0,090	70	FF	0,071	77
Şanlıurfa	DD	0,213	53	FF	0,020	78	FF	0,064	78
Mardin	FF	0,074	77	FF	0,010	79	FF	0,054	79
Muş	FF	0,064	80	FF	0,010	80	FF	0,026	80
Şırnak	FF	0,000	81	FF	0,000	81	FF	0,000	81

APPENDIX 4. RANKINGS OF PROVINCES IN ASO-İLTEK AND ITS COMPONENTS FOR 2023-2025

Province	Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index		
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025
Adana	CC	CC	CC	DD	DC	DD	BA	BA	BB	DC	DC	DD	CC	DC	DC
Adiyaman	DD	FF	FF	DD	FF	FF	BA	AA	BA	CB	DD	DD	DD	DD	FF
Afyonkarahisar	FF	FF	FF	FF	FF	FF	CB	CB	CC	FF	FF	FF	CB	CB	DC
Ağrı	CC	DD	DC	FF	FF	FF	DC	DC	DC	FF	FF	FF	DD	DD	FF
Aksaray	FF	FF	FF	FF	FF	FF	BA	BB	CB	FF	DD	DD	CB	CB	DC
Amasya	FF	FF	FF	FF	FF	FF	BA	BB	CB	FF	FF	DD	BB	CB	CB
Ankara	AA	AA	AA	AA	AA	AA	BA	AA	BA	AA	AA	AA	BA	AA	BA
Antalya	CC	CC	CC	DD	DC	DD	BA	BB	BB	DC	DC	DC	BA	BA	AA
Ardahan	FF	FF	FF	FF	FF	FF	BB	BB	CB	FF	FF	FF	CB	AA	AA
Artvin	FF	FF	FF	FF	FF	FF	BA	BB	CB	FF	FF	FF	BB	CB	BA
Aydın	FF	FF	FF	DD	FF	DD	CB	CB	CC	DC	DC	DD	BA	CB	CB
Balıkesir	FF	DD	DC	FF	FF	FF	CB	CB	CC	DC	DC	DD	BA	BA	AA
Bartın	FF	FF	FF	FF	DD	FF	CC	CC	DC	FF	DC	FF	BA	BA	BB
Batman	CC	CC	DC	FF	FF	FF	FF	FF	FF	FF	FF	DD	DD	FF	FF
Bayburt	DD	FF	FF	FF	FF	FF	DC	DC	DC	FF	DC	DD	CC	CB	CB
Bilecik	DD	DD	FF	DC	CB	CC	CB	CB	CC	CB	DD	CC	BA	CB	CB
Bingöl	FF	FF	FF	FF	FF	FF	FF	DD	FF	FF	FF	FF	CB	CB	DD
Bitlis	DD	FF	FF	FF	FF	DD	FF	FF	FF	FF	FF	FF	DC	DC	DD
Bolu	DC	CC	DC	DD	DC	DD	CB	CC	DC	FF	FF	DD	BA	BA	BA
Burdur	FF	FF	FF	FF	DC	FF	DC	DC	DC	DC	CC	CC	BA	BA	BB
Bursa	CC	CC	CB	CC	CB	CC	BB	BB	CB	AA	AA	AA	BB	CB	DC
Çanakkale	DD	DD	DC	DD	DC	DD	CB	CB	CC	DD	CC	DC	AA	AA	AA
Çankırı	DD	FF	FF	DC	DC	FF	CB	CB	CB	DD	CC	CC	CC	BA	CB

Province	Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index		
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025
Çorum	DD	DD	DC	FF	FF	FF	CB	CB	CC	DC	FF	DD	CC	DC	DC
Denizli	DC	DC	DC	DC	DC	CC	CB	CB	CC	CB	CB	CB	BA	BA	BB
Diyarbakır	CC	CC	DC	FF	FF	FF	FF	DC	DC	FF	FF	FF	DD	FF	FF
Düzce	CC	CB	CB	CC	CB	DD	DC	DC	DC	DC	CC	CC	BA	BA	CB
Edirne	CC	CC	DC	DD	DC	FF	BB	BB	CB	FF	FF	FF	AA	AA	AA
Elazığ	CC	DD	DC	CC	CB	CC	CC	CC	CB	FF	DC	CC	CC	DC	DC
Erzincan	FF	DD	FF	FF	FF	FF	DC	DC	FF	FF	FF	FF	BB	BB	BB
Erzurum	DD	DD	DC	DD	DC	DD	DC	DC	FF	DC	DC	CC	CC	CB	CB
Eskişehir	BB	BB	BB	AA	AA	BA	BA	BB	CB	CB	AA	AA	AA	BA	BB
Gaziantep	DD	DD	DC	DD	FF	FF	CB	CB	CC	CB	CB	CC	FF	FF	FF
Giresun	FF	FF	FF	FF	FF	FF	DC	DC	FF	FF	FF	DD	CB	CB	CB
Gümüşhane	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	CC	DC	CB
Hakkari	DC	DD	DC	FF	FF	FF	FF	DD	DC	FF	FF	FF	FF	FF	FF
Hatay	FF	FF	FF	FF	FF	FF	CB	BB	DC	DD	FF	DD	CC	DC	FF
Iğdır	CC	DD	CB	FF	DD	FF	FF	FF	FF	FF	FF	DD	DC	DC	DC
Isparta	DD	DD	DC	CC	CB	CC	CB	CB	CB	DC	CC	CB	BA	BA	BB
İstanbul	AA	AA	AA	BB	BA	BA	AA	AA	AA	AA	AA	AA	BB	BA	BB
İzmir	BB	BB	BB	CB	CB	CB	BA	BA	BB	BB	BB	BB	BA	BA	BB
Kahramanmaraş	DD	DD	DC	DD	FF	DD	DC	CC	CC	DD	DC	DD	FF	DD	FF
Karabük	FF	DD	DC	CC	BA	CC	CB	CC	CC	DC	CC	CC	BA	BA	CB
Karaman	FF	FF	FF	DD	DC	DD	DC	DC	DC	CB	CB	CB	BB	BA	CB
Kars	CC	CC	CB	FF	FF	FF	FF	DC	FF	FF	FF	FF	CC	CB	CB
Kastamonu	FF	FF	FF	FF	FF	FF	DC	DC	DC	FF	DC	DC	BA	BA	BB
Kayseri	CC	CC	CC	DC	CB	CC	CB	CB	CB	BA	AA	AA	CC	CC	DC

Province	Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index		
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025
Kırıkkale	FF	DD	CB	DD	DC	DD	CC	DC	DC	FF	FF	FF	BB	CB	DC
Kırklareli	BB	CC	CB	FF	DC	FF	DC	DC	FF	FF	FF	DD	AA	AA	BA
Kırşehir	FF	FF	FF	FF	FF	FF	DC	DC	DC	FF	DC	DD	CB	CB	DC
Kilis	FF	FF	DC	FF	FF	FF	BA	AA	BB	FF	FF	DD	FF	DD	DD
Kocaeli	BA	BB	BA	BA	BA	BA	BB	BB	BB	BB	BB	BB	AA	AA	BA
Konya	DD	DD	DC	DD	DC	DD	CB	CB	DC	BB	BB	BB	CC	CB	CC
Kütahya	FF	FF	FF	CC	CB	CC	CB	CB	DC	DD	DC	CC	BA	BA	BB
Malatya	DC	DD	DC	DD	DC	DD	CB	BB	CB	CC	DC	DD	CC	CB	DC
Manisa	BB	CB	CB	DD	DC	DD	DC	DC	DC	CB	BB	CB	BA	BA	CB
Mardin	FF	FF	FF	FF	FF	FF	FF	FF	FF	DC	FF	FF	FF	FF	FF
Mersin	DD	DD	DC	DD	FF	DD	DC	DC	DC	DC	DC	DC	CB	CB	CB
Muğla	DD	DD	DC	FF	FF	FF	BA	BB	CB	FF	FF	DD	AA	AA	AA
Muş	FF	FF	FF	FF	FF	FF	FF	FF	FF	DD	FF	FF	DD	DC	FF
Nevşehir	FF	FF	FF	FF	DD	FF	DC	DC	DC	DD	CB	DD	BB	BA	AA
Niğde	FF	DD	DC	DC	CB	CC	DC	DC	DC	FF	DC	CC	DC	DC	DC
Ordu	FF	FF	FF	FF	FF	FF	DC	DC	DC	FF	FF	DD	CB	CB	CB
Osmaniye	FF	FF	FF	FF	FF	FF	DC	DC	DC	FF	FF	DD	DC	FF	FF
Rize	DD	DD	DC	DD	DC	DD	CB	CB	CC	DC	DC	DC	BA	BA	BB
Sakarya	DC	CC	CC	CC	CB	CC	CB	CB	CC	AA	BB	BA	BA	BA	CB
Samsun	DD	DD	DC	DD	DC	CC	CB	CB	CB	DC	DC	DC	BB	CB	CB
Siirt	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	CB	FF	FF	DD	FF
Sinop	FF	FF	FF	FF	FF	FF	DC	DC	FF	FF	FF	FF	BA	BA	AA
Sivas	BB	CC	CC	DD	DC	DD	DC	DC	CC	DC	FF	DD	CB	CB	DC
Şanlıurfa	AA	FF	FF	FF	DC	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Province	Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index	
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2025
Şırnak	FF	FF	FF	FF	FF	FF	FF	FF	FF	DC	DC	FF	FF	FF
Tekirdağ	BB	BB	BB	CC	CB	CC	CB	CB	CC	DC	DC	CC	BA	CB
Tokat	DD	DD	DC	FF	FF	FF	DC	DC	FF	DC	CB	DC	CB	DC
Trabzon	DD	DD	DC	CC	CB	CC	BB	BB	BB	DC	DC	CC	CB	BB
Tunceli	FF	FF	FF	FF	FF	FF	DD	FF	FF	FF	DC	DD	CB	BB
Uşak	FF	FF	FF	FF	FF	FF	CB	CB	CB	FF	FF	FF	BA	CB
Van	DD	DD	DC	DD	DC	FF	FF	FF	DC	FF	FF	FF	FF	FF
Yalova	DD	DD	DC	DD	DC	DD	CB	CC	DC	DC	CB	DD	BA	CB
Yozgat	FF	FF	FF	DD	FF	FF	CC	CC	DC	FF	FF	FF	CC	DC
Zonguldak	FF	FF	FF	FF	FF	FF	CB	BB	CC	FF	DC	DD	BA	DC

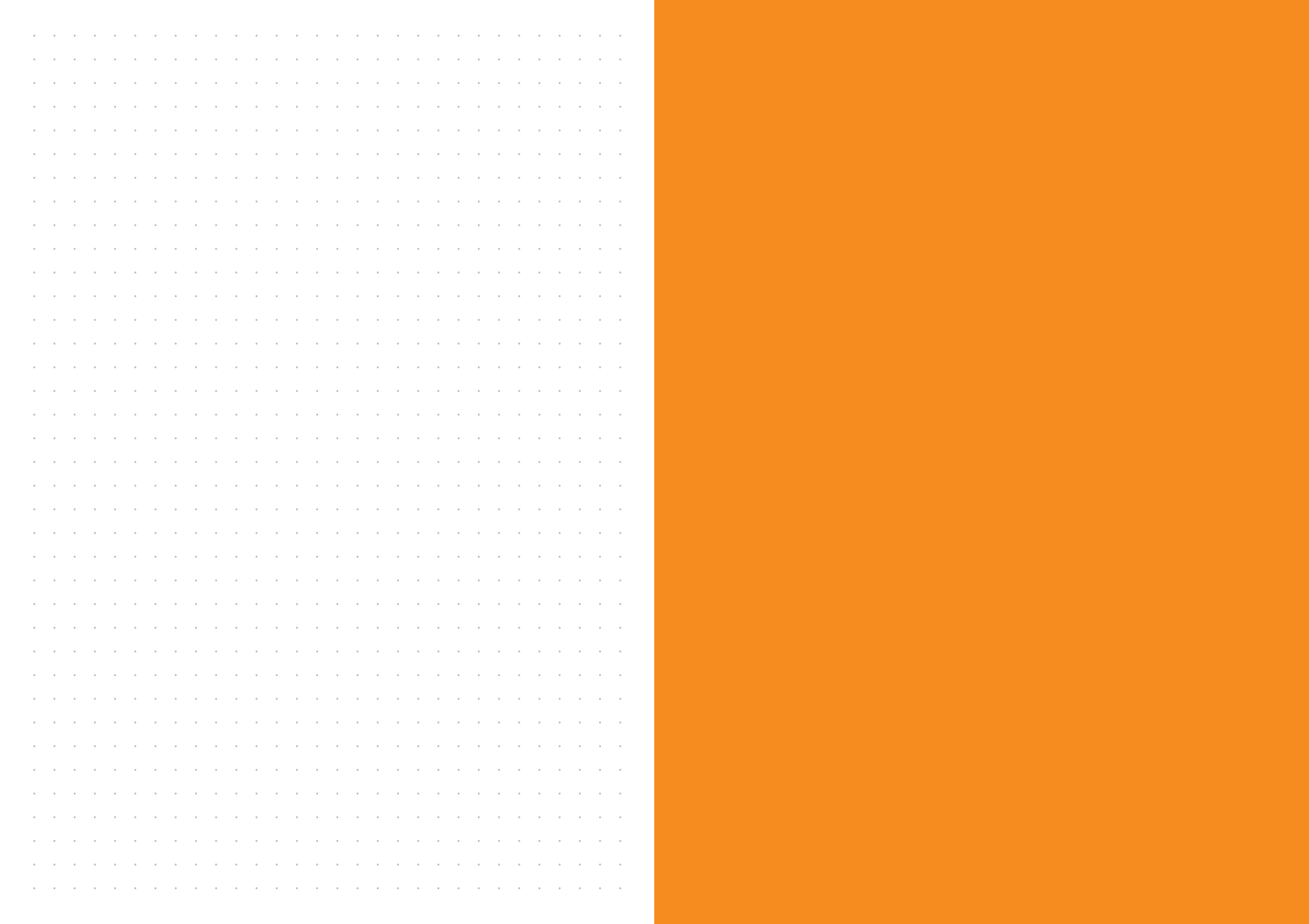


APPENDIX 5. RANKINGS OF PROVINCES IN ASO-İLTEK AND ITS COMPONENTS FOR 2023-2025

Province	ASO-İLTEK			Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index	
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2025
Adana	23	21	19	19	15	15	26	32	25	7	5	6	27	44	35	58	61
Adıyaman	28	43	32	38	54	63	36	53	38	5	4	3	16	48	34	68	70
Afyonkarahisar	54	56	55	66	68	70	53	56	45	29	38	27	48	52	60	47	52
Ağrı	67	68	70	12	25	39	79	79	77	65	55	51	71	72	80	72	69
Aksaray	46	52	46	65	71	68	67	73	40	10	11	13	58	49	47	48	56
Amasya	41	48	48	75	73	59	63	70	72	9	8	17	54	56	49	34	46
Ankara	1	1	1	1	2	1	1	1	1	2	3	2	2	3	3	12	7
Antalya	12	13	10	22	14	16	27	34	30	6	7	7	24	25	28	14	12
Ardahan	51	49	56	74	81	81	73	74	76	13	10	18	73	80	74	45	4
Artvin	39	54	49	77	77	72	64	68	78	8	14	16	45	77	65	36	41
Aydın	34	41	38	59	55	55	35	42	36	25	29	28	29	40	38	17	34
Balıkesir	31	32	34	52	43	44	48	48	50	21	25	35	36	39	54	10	11
Bartın	49	40	57	68	58	60	51	39	51	44	43	45	60	30	72	27	30
Batman	70	71	73	13	18	35	60	55	64	74	73	75	63	64	55	69	75
Bayburt	66	59	59	45	57	52	69	69	70	58	57	53	69	41	44	59	52
Bilecik	21	25	28	44	22	51	18	15	18	37	31	29	14	47	22	29	39
Bingöl	75	73	75	70	75	80	71	72	48	69	70	70	76	66	66	64	53
Bitlis	76	76	72	36	50	67	72	71	31	79	78	73	65	79	77	66	65
Bolu	30	19	26	24	20	21	24	20	22	39	40	49	50	24	37	22	10
Burdur	35	34	45	73	76	75	49	23	53	49	54	50	15	20	15	16	18
Bursa	6	6	7	17	10	13	7	9	8	16	13	12	3	2	2	38	44
Çanakkale	24	20	24	42	33	36	33	37	28	18	26	34	41	22	26	5	6
Çankırı	36	29	30	41	62	49	19	26	42	23	28	19	39	18	17	54	25

Province	ASO-İLTEK			Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index		
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025
Çorum	52	57	52	46	44	45	59	65	71	34	35	33	28	51	40	57	61	57
Denizli	14	14	13	26	21	22	17	19	17	20	22	31	13	13	12	25	29	15
Diyarbakır	69	67	63	16	13	25	54	64	56	71	65	47	55	61	67	71	77	77
Düzce	10	11	16	11	7	9	6	8	19	53	49	55	19	19	16	7	23	28
Edirne	13	17	25	20	17	19	21	29	39	15	17	22	61	65	62	2	2	3
Elazığ	38	23	20	21	30	26	14	6	14	42	41	24	51	37	18	62	59	58
Erzincan	60	61	65	49	47	53	58	58	61	62	62	64	64	76	76	33	33	26
Erzurum	50	38	37	34	35	31	31	21	23	66	60	66	30	43	23	53	43	34
Eskişehir	3	3	3	5	4	4	2	2	4	11	12	10	11	4	5	6	8	16
Gaziantep	42	39	33	35	39	40	40	46	33	32	21	26	10	12	14	74	73	68
Giresun	65	69	68	78	79	76	62	60	66	61	64	67	70	69	57	40	48	30
Gümüşhane	73	75	76	60	59	56	57	51	62	77	79	79	68	74	69	51	62	42
Hakkari	78	77	74	23	29	29	81	81	81	70	69	63	81	81	81	80	80	76
Hatay	57	58	62	67	65	61	52	57	47	40	19	43	43	57	50	61	66	71
İğdır	72	65	42	18	27	7	70	40	46	72	72	68	72	59	42	65	64	60
Isparta	19	16	12	30	26	23	10	12	15	30	30	23	34	23	10	24	17	17
İstanbul	2	2	2	2	1	2	4	4	3	1	1	1	1	1	4	37	24	23
İzmir	5	5	5	9	5	5	5	7	5	4	6	5	8	9	9	11	14	24
Kahramanmaraş	62	55	47	37	40	41	37	49	29	57	39	30	40	45	36	73	71	74
Karabük	18	10	21	56	42	37	11	5	16	33	42	25	23	21	19	8	15	44
Karaman	25	36	39	76	70	69	32	31	34	50	48	61	9	14	13	32	32	37
Kars	64	53	54	15	11	12	61	59	67	68	68	65	79	63	70	50	40	35
Kastamonu	47	47	53	62	63	58	44	54	58	52	58	58	62	36	32	15	9	19
Kayseri	8	7	6	14	12	17	15	16	6	22	23	14	5	5	1	52	58	56

Province	ASO-İLTEK			Sectoral Structure			Research and Innovation Capacity			Digital Infrastructure			Technology Outputs			Quality of Life and Workforce Attractiveness Index		
	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025	2023	2024	2025
Kırıkkale	40	50	44	54	41	11	28	27	35	43	52	44	46	71	73	31	35	62
Kırklareli	22	35	36	8	9	10	42	38	44	59	66	71	59	73	52	4	5	10
Kırşehir	61	62	64	69	78	78	65	62	59	51	51	56	47	42	45	44	54	53
Kilis	48	42	35	48	48	46	74	66	69	3	2	4	57	68	58	77	68	66
Kocaeli	4	4	4	4	3	3	3	3	2	17	9	8	7	7	8	3	3	13
Konya	15	18	14	28	31	28	22	24	21	38	32	42	6	8	7	56	55	47
Kütahya	29	24	18	61	52	47	13	14	9	41	37	41	37	35	21	23	16	14
Malatya	37	30	29	27	32	34	39	33	24	36	18	11	17	46	51	60	38	54
Manisa	11	12	15	10	8	8	25	22	20	56	56	60	12	10	11	19	20	33
Mardin	77	79	79	57	66	62	80	80	80	75	75	77	33	60	63	78	76	78
Mersin	43	46	43	33	34	33	41	43	37	54	59	59	21	28	29	43	50	40
Muğla	20	22	23	39	36	42	47	52	63	12	15	15	56	62	39	1	1	1
Muş	80	80	80	50	61	71	75	75	74	80	80	80	42	75	79	70	67	69
Nevşehir	45	37	40	53	56	57	43	41	43	47	53	54	38	17	33	30	27	5
Niğde	56	45	22	51	45	43	16	17	7	55	61	46	80	33	20	63	60	59
Ordu	59	63	60	63	67	64	77	78	75	48	46	48	49	54	43	42	49	39
Osmaniye	71	72	71	72	72	74	56	61	65	60	50	62	74	53	56	67	74	67
Rize	27	27	27	40	38	30	20	25	26	28	33	38	35	31	30	21	21	21
Sakarya	7	8	8	25	19	18	12	10	10	26	27	36	4	6	6	28	26	32
Samsun	26	28	17	32	23	24	23	30	12	24	24	21	25	29	31	35	37	36
Silirt	79	70	77	64	64	73	66	63	68	73	76	72	66	16	59	76	70	73
Sinop	63	64	66	80	74	77	76	76	73	64	67	74	53	50	61	20	19	7
Sivas	17	33	31	6	16	14	30	18	27	46	47	39	18	55	46	46	45	51
Şanlıurfa	53	78	78	3	49	54	50	35	41	78	77	78	77	78	71	79	81	79





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