Ankara Sanayi Odası

TECHNOLOGICAL DEVELOPMENT INDEX OF PROVINCES

ASO İLTEK

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TECHNOLOGICAL DEVELOPMENT INDEX OF PROVINCES

DECEMBER 2024

ASOİLTEK

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ABBREVIATIONS

EU	: European Union
US	: United States
AI	: Artificial Intelligence
R&D	: Research and Development
ASO	: Ankara Chamber of Industry
ICT	: Information and Communication Technologies
ECI	: Economic Complexity Index
EDAM	: Economic and Foreign Policy Research Centre
ESPAS	: European Strategy and Policy Analysis System
Eurostat	: Statistical Office of the European Union
FREI	: Future Readiness Economic Index
FTRI	: Readiness for Frontier Technologies Index
GII	: Global Innovation Index
GDP	: Gross Domestic Product
IBBS	: Classification of Statistical Regional Units
IoT	: Internet of Things
ISO	: İstanbul Chamber of Industry
SME	: Small and Medium Enterprises
SDG	: Sustainable Development Goals
KOSGEB	: Small and Medium Enterprises Development Organisation

NACE	: Statistical classification of economic activities in the European Community
OECD	: Organisation for Economic Cooperation and Development
PCA	: Principal Component Analysis
PCI	: Productive Capacities Index
SEGE	: Socio-Economic Development Ranking Research
SSI	: Social Security Institution
PPP	: Purchasing Power Parity
STEM	: Science, Technology, Engineering and Maths
TEYDEB	: Directorate of Technology and Innovation Support Programmes
TÜBİTAK	: Scientific and Technological Research Council of Türkiye
TÜİK	: Turkish Statistical Institute
TURBIS	: Turkish Enterprise and Business Confederation
TÜRKONFED	: Turkish Business Confederation
UNCTAD	: United Nations Trade and Development Organisation
UR-GE	: Development of International Competitiveness
WIPO	: World Intellectual Property Organisation
WTO	: World Trade Organisation
YOİKK	: Coordination Board for the Improvement of the Investment Environment


NAYİ ODAS

PREFACE

Seyit ARDIÇ
Ankara Chamber of Industry
Chairman of the Board

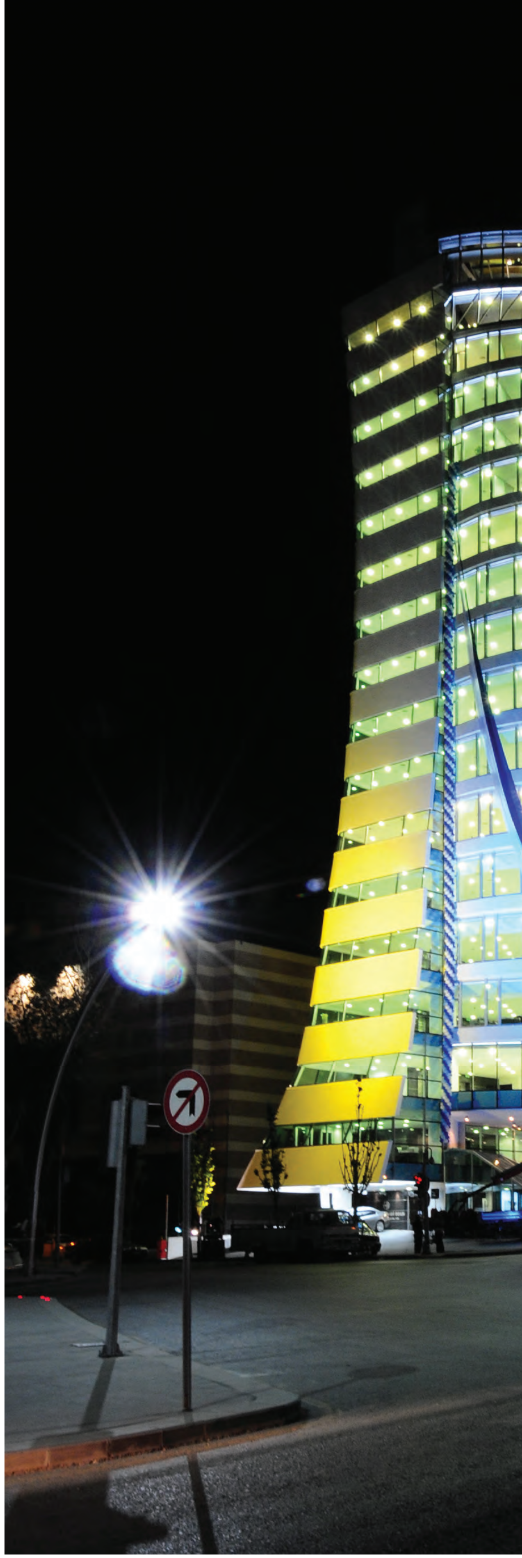
The Ankara Chamber of Industry (ASO) uses the experience and expertise it has gained in its 61-year deep-rooted history for the benefit of Ankara's industry, and contributes to the future vision of our capital province and our country through innovative projects and activities. Our vision is to transform Ankara into the capital of industry and technology. To this end, our Chamber supports the healthy execution of the digital and green transformations, thus ensuring that companies can be more strongly integrated into the global value chain, while creating an innovative ecosystem with high added value. Furthermore, the high-quality analyses and studies we have conducted are contributing to evidence-based policy-making based on the identification of national trends, opportunities and risks, and are a significant source of data within the information infrastructure in support of economic actors. We are proud to be signing our name under another important work supporting our country in reaching its sustainable development goals (SDG) and in gaining strength through its technological transformation.

The comprehensive Ankara Chamber of Industry Technological Development Index of Provinces (ASO-İLTEK) study evaluates the technological development level of Türkiye on a provincial basis, creating a map of Türkiye's digital infrastructure, innovation capacity, sectoral structure, technological outputs and quality of life. We believe that the index will contribute to the improvement of our country's global competitiveness by increasing the interactions of our technology providers at the national level.

ASO-ILTEK aims to support all our regions in adapting to the technological and digital transformation by identifying the strengths and weaknesses of each province, rather than being a ranking based solely on technological indicators. The results of the study reveal which provinces are in need of more support and investment for the technological development of our country. In this regard, we believe that the index will serve as a comprehensive guide for policymakers.

At a time when the global economy is rapidly evolving on the axes of digitalisation, sustainability, and innovation, ASO-ILTEK can be said to make important contributions to the determination of our future competitiveness. We hope that this data will support strategic decision-making not only among the nation's industrialists and business persons, but also central and local government, academia, and investors. We foresee that ASO-ILTEK will serve as a key resource contributing to our country taking appropriate steps in its transition to a technology-based growth model.

According to ASO-ILTEK data, Ankara and İstanbul stand out as the leading provinces in Türkiye's technology-oriented transformation, and are attracting international attention with their high R&D capacities and digital infrastructures. However, these two provinces lag significantly behind their deserved positions in global indexes. The innovation-focused and high-tech orientated activities focused in Ankara and İstanbul will contribute to raising Türkiye's position in the global technology ecosystem. As ASO, we are committed to supporting this and strengthening our country's position in the global economy through increased international competitiveness.



We would like to express our sincere thanks to Prof. Dr. Güven Sak, Founding Director of the Economic Policy Research Foundation of Türkiye (TEPAV) and to Mr. H. Ekrem Cunedioğlu, Programme Director, for their collaboration in this valuable study. We also extend our gratitude to Prof. Dr. Nuri Yavan and Prof. Dr. İbrahim Semih Akçomak for the technical support they provided. We also give thanks to Prof. Dr. Mehmet Cansız, the Secretary General of our Chamber and ASO Technopark A.Ş., for his diligent contributions to every stage of this project, from the idea stage right up to its implementation and finalisation, to ASO General Manager ASO Technopark A.Ş. Deputy Secretary General Ahmet Dinçer, to Entrepreneurship and Innovation Manager Seda Aydın and to all ASO employees who contributed to the study.

EXECUTIVE SUMMARY

The Ankara Chamber of Industry Technological Development Index of Provinces (ASO-İLTEK) is a comprehensive and comparative analysis of the technological development levels of Türkiye at a provincial level. The index presents a regional technology map of Türkiye detailing the performance of different provinces in categories such as digital infrastructure, research and innovation capacity, sectoral structure, technological outputs, quality of life and labour attractiveness. In addition to assessing the technological development performance of provinces, the Index also reveals the adaptation capacities of geographically close provinces to the global trends of regional technology belts. This index, the first of its kind in Türkiye, is planned to be published annually. It aims to provide the essential data and analytical framework needed to design technology-based and regionally focused industrial policies. In this context, the index is expected to serve as a key reference document for policymakers at both the local and national levels.

The Challenge of Global Transformation and the Need for an Interventionist Approach

The main trends and transformations shaping the development and structural change of the global economy manifest their effects at different scales. The rapid development of technologies, the emergence of innovation-oriented competitiveness, the acceleration of "creative destruction" processes and the shortening of product life cycles over the last 50 years have put pressure on companies to innovate, increase productivity and transform. Furthermore, the rapid population growth, the climate change brought about by industrialisation and the deterioration of ecological balance have led countries and companies to allocate more time and resources to the twin transformation processes. On the other hand, the structural crises in the global supply chain that first emerged during the COVID-19 pandemic have brought regional-focused approaches to the agenda. Digital transformation, technological innovation, the sustainability, demographic changes, responses to the evolution of global trade and the micro or macro policies developed in these areas will determine the positions of countries and companies in the new economic era.

Türkiye's Place in Global Technology Development and Regional Differences

Megatrends in the global economy, such as digitalisation, Artificial Intelligence (AI) and the sustainable green transformation create new opportunities for countries, but also impose considerable pressure on innovation and productivity. Although Türkiye has made progress in areas such as digital infrastructure and the production of high-tech products, there are noticeable provincial differences in the levels of technological development. Similar disparities can be observed not only between Türkiye's provinces, but also between its two most technologically advanced provinces and the world's leading provinces. These gaps hinder Türkiye's ability to gain a strong position in the global technology race and contribute to its lower rankings in international indexes related to technology and competitiveness. Türkiye's average ranking of 47th in the UNCTAD-FTRI (Frontier Technology Readiness Index), WIPO-GII (Global Innovation Index) and Descartes Institute-FREI (Future Readiness Economic Index) clearly highlights the significant progress that still needs to be made. In order to develop the innovative and reactive policies needed to keep up with the so-called megatrends, consistent data sets are required to clarify the current situation and future perspectives.

Necessity and Purpose of the Index

ASO-ILTEK has been developed as an innovative tool for the measurement of Türkiye's regional technological and innovative infrastructure, as well as provincial development levels. ASO-ILTEK comprehensively evaluates the extent to which provinces can adapt to technology, as well as their innovation capacities, their preparations for digitalisation, their contributions to research and their qualified human resources. It thus aims to contribute to policy development as a reliable database that can be referenced by local and national policy makers when developing technology-oriented economic growth strategies for the country aimed at reducing its technological development gaps. The intention in this regard should be to bring our technologically strong provinces to the same level as the internationally developed provinces around the globe, to encourage innovative projects and R&D investments, and to take full advantage of cooperation opportunities. Another objective of the index is to provide a detailed analysis of Ankara's existing strengths and potential, thereby enabling the formulation of policy recommendations tailored to the local context.

The data provided by the index will allow the identification of the regions in Türkiye in which the digital infrastructure is lacking, as well as those in need of technological development, to steer the direction of the strategic steps to be taken. Although there are existing indexes measuring socio-economic development in Türkiye, ASO-ILTEK focuses specifically on technology to reveal the extent to which provinces are ready for the technological transformation. ASO-ILTEK takes a different approach to traditional development indexes and is thus expected to contribute to the creation of a technology-based growth model for Türkiye.

The ASO Technological Development Index of Provinces assesses 37 variables and five sub-indexes for its measurement of the level of technological readiness of the 81 provinces in Türkiye. The index comprises a Sectoral Structure Sub-Index (2 variables), a Research and Innovation Capacity Sub-Index (11 variables), a Digital Infrastructure Sub-Index (4 variables), a Technology Outputs Sub-Index (4 variables) a Quality of Life and Labour Attractiveness Sub-Index (16 variables). In the statistical evaluation of the 37 variables for each province, a value of 1 indicates the highest level of technological development, while a value of 0 indicates the lowest level.

The highest ranking provinces in terms of technological development are Ankara, İstanbul, Eskişehir, and Kocaeli, which are ranked first, second, third, and fourth respectively, followed respectively by İzmir, Bursa, Kayseri, and Sakarya. Another striking point regarding the index results is that the ranking of the provinces based on sub-index scores has changed significantly. For example, in the Quality of Life and Labour Attractiveness sub-index, the rankings of Ankara (7), Istanbul (24), Bursa (44), and Kayseri (58) are significantly lower than their positions in the overall index. It can thus be understood from an analysis of the ASO-ILTEK sub-indexes that different factors contribute to the rankings of the provinces, either driving them up or pulling them down.

A regional analysis of indexes reveals two main technology generators in Türkiye: the İstanbul-Kocaeli belt, centred in İstanbul, and the Ankara-Eskişehir belt, centred in Ankara. These two potential generators, which are close to each other geographically, are considered accelerators in the overall technological development of the country.

One of the conclusions of the report is that Türkiye's two largest provinces, İstanbul and Ankara can both be considered centres of technology development and innovation. They are significantly ahead of other provinces in terms of digital infrastructure and R&D capacity development. This is largely due to the lack of momentum in these areas in less socio-economically developed regions. The fact that certain provinces lag behind in such fields as R&D investments, high-tech production, and exports limits Türkiye's overall innovation capacity and technology-based development potential.

ASO 2. ve 3. OIZ/ Ankara

In other words, Türkiye's high-tech manufacturing and exporting enterprises are concentrated in certain provinces, along with their R&D operations. This asymmetric distribution is a key factor that limits Türkiye's overall innovation capacity and restricts the progress of provinces with technology-based development potential. ASO-ILTEK reveals the regional imbalances and difficulties faced in the country and presents important clues as to why certain provinces have failed to realise a technological transformation.

The report reveals that Ankara and İstanbul have the potential to increase their competitiveness in the international arena on the strength of their strong digital infrastructures, R&D capacities, and innovation ecosystems. However, both provinces currently lag behind in global competition indexes. If these two provinces can sustain their development in the high-tech and innovation-oriented sectors, Türkiye can assume a more active role in global value chains. Ankara and İstanbul's progress in attracting international investments and high value-added production will contribute to Türkiye gaining a stronger position in the global technology arena.

> ASO-ILTEK, which was developed to map Türkiye's technological development, strikingly reveals the dimensions of the technology capacity gap between provinces.

Policy Recommendations Based of Prominent Findings

As can be understood from the index data and findings, it is of critical importance to take steps to reduce the observed technlogical development gaps between Türkiye's provinces if it is to achieve its sustainable and technology-oriented development goals. ASO-ILTEK provides a clear identification of the provincial disparities. It also emphasises the need for a long-term sustainable technology policy to balance Türkiye's regional development levels. The main policy recommendations presented in the report targeting Türkiye's technology-based development are presented below:

- **Supporting High Technology Production:** The number of enterprises engaged in the production of high value-added products in technology-intensive sectors should be increased to accelerate Türkiye's technological development and production activities should be spread throughout the country rather than being focused only in the metropolises. Supporting the development of technology-intensive sectors especially in the Anatolian provinces would be an effective approach to the reduction of Türkiye's technological development gap.

- **Strengthening R&D and Innovation Capacity:** To increase Türkiye's technology production capacity, it is of great importance to encourage R&D investments and improve university-industry cooperation. To this end, the effectiveness of technoparks, technology transfer offices, incubation centres, and entrepreneurship support programmes should be increased and R&D activities should be spread over a wider geographical area.

- **Development of the Digital Infrastructure:** It is important to improve broadband Internet access and Internet speeds throughout Türkiye, as a fundamental factor in the digital transformation process. Providing fast and reliable Internet throughout the country will allow regions that lag behind in the digitalisation process to participate more effectively. Strengthening the digital infrastructure will further facilitate access to technology in all provinces and increase the speed of the digital transformation.

- **A New Clustering Strategy:** The provision of support for clustering provided by different institutions since the 2000s has failed to become widespread. In most clusters, horizontal and vertical cooperation between companies has not reached the desired level. Practices such as risk sharing and competing through cooperation remain underdeveloped. Input-output analyses, mapping, network behaviour of clusters, and the benefits and impacts of acting together could not be measured. A new clustering approach should be developed that take into account the different competences of provinces and the existence of potential for technology generation in Türkiye.

- **Improving the Quality of the Labour Force and Attracting Innovative Human Resources:** To meet Türkiye's need for a qualified workforce in its technology-intensive sectors, STEM (Science, Technology, Engineering and, Mathematics) education programmes should be expanded. Furthermore, qualified foreign experts should be sought who can boost Türkiye's innovation and technology development capacity.

- **Strengthening Local Technology Ecosystems:** To accelerate regional development, it is essential to establish technology ecosystems at the local level and ensure greater involvement of local governments in these processes. Supporting industrial clusters in particular can accelerate the technological adaptation of provinces. By strengthening local technology ecosystems, regional disparities can be reduced and technology-based economic growth can spread throughout the entire country.

- **Supporting the Green Transformation:** The use of environmentally friendly technologies and the promotion of sustainable production models will increase Türkiye's competitiveness in international markets. In this context, green financing models should be developed that encourage companies to make investments that reduce their carbon footprints, and the green transformation should be encouraged in all national technology policies.

- **Ensuring product and market diversification in technology-intensive sectors:** In order to reduce dependence on specific regions and expand access networks, it is important to review existing trade agreements with a view to both facilitating access to foreign markets and protecting domestic industry. This consideration should also be taken into account when negotiating new agreements.

In conclusion, the ASO Technological Development Index of Provinces study aims to contribute significantly to Türkiye's technological development and innovation potential by providing a solid source of data that can steer the development of national and regional policies. It is believed that regular yearly index studies will be of critical importance for the monitoring of the changes in Türkiye's technological infrastructure, allowing strategic steps to be taken accordingly. Annual analyses will allow progress in the provinces in the fields of technology and innovation to be monitored in more detail and strengths and weaknesses to be clearly identified.

This preliminary study will be developed in the coming periods in cooperation with public and private sector stakeholders. After measuring the technological development levels of the provinces, target-oriented policies should be determined for each province to create a sustainable growth model in the fields of technology and innovation. The ultimate goal is to increase Türkiye's competitiveness by advancing its technology and innovation levels, thus securing it a stronger position in the global economy.

INTRODUCTION

Over the past quarter-century, the world has been undergoing a rapid, profound, and multi-dimensional transformation, marked by the shift from an information society to a digital society. This transformation has brought about significant socio-economic and cultural changes. These changes are placing increasing pressure on public institutions, universities, individuals, and companies—particularly particularly under the concepts of production, consumption, trade, and distribution. This pressure is reshaping global trade as well as demographic structures, while the concepts of sustainability and technology are increasingly featured on economic and social agendas. The desire for environmental sustainability ensures that green transformation remains a strategic priority. Meanwhile, increasing carbon emissions continue to underline its urgency, while competition in production processes is accelerating the technological transformation. Furthermore, the growth of such innovative technologies as digitalisation, artificial intelligence, and automation is reshaping labour markets, optimising production processes, and driving the creation of new business models. The ability of countries to adapt economically and technologically to these rapid development and transformation processes will determine the size of their share in global distribution or accentuate their differences with other countries.

In this regard, countries are implementing policies of different intensity and scale to support their structural transformations and enhance their adaptive capacities. Countries such as China and the United States are making significant investments into their public and private sectors to maintain their leading positions in the global technology race, while Europe is focused more on sustainability-oriented policies.

According to World Bank data, the share of global R&D expenditures in GDP increased from 1.93 percent in 2011 to 2.62 percent in 2021, of which 36 percent was in the United States, and 27.7 percent was in China. On the other hand, the fact that 47.2 percent of all international patent applications (totalling 3,552,100) in 2023 were made by China and 16.8 percent by the United States suggests that China's influence in the global technology scene will gradually increase in the coming period.

> "The surge in R&D spending and patent applications signals that China is poised to become a global powerhouse in the tech scene."

In the European Union, all sectors are being restructured to achieve both technological and environmental transformation, driven by decisive policies that include the 2050 net zero emission target. Actions that reconsider supply chain processes and emphasize the circular economy, such as the Critical Raw Materials Law demonstrate the European Union's commitment to this goal. These steps have been taken despite the high investment costs involved. It is estimated that the European Union will incur costs amounting to 10 percent of its GDP in the achievement of the climate-neutral target, amounting to around €40 trillion by the end of the period. The stance of other countries towards the technology and climate policies of politically and economically influential nations tends to be shaped by adaptation and reaction.

In particular, the digital and green transformations have reshaped economic and technological dynamics, while the COVID-19 pandemic and the resulting structural disruptions in global supply chains have increased the need for countries and provinces to revisit their economic development policies. Resilient economic models, localised production activities and investments into strategic technologies provided the foundation for the rise of new industrial policies. In this context, the reconsideration of local development strategies from a technology-oriented perspective has made it necessary to develop policies that support not only economic growth but also sustainability. The appropriateness of such policies for the purpose and the speed at which they can be implemented will be important factors determining the success of countries in improving their innovation and technological capacities at a global scale.

While Türkiye has significant potential for digital transformation and technology-driven economic growth, it also faces several structural challenges. Türkiye's position in three indexes (WIPO-GII, UNCTAD-FTRI, Descartes Institute-FREI) comparing the technological sophistication of countries confirms the presence of these challenges. In particular, the country's digital infrastructure, human capital, institutions, industrial activity, information and communication technologies, R&D capacity and qualified human resources need to be improved if Türkiye is to improve its position in these indexes and thus strengthen its position in the competitive global economy.

ASO 1. OIZ/ Ankara

> The advanced technological infrastructure in Istanbul and Ankara offer opportunities and pathways for global competitiveness.

While Türkiye maintains a strong position in terms of product and market diversity and ranks sixth in the world in terms of the number of competitively exported products, high-tech products represent only 3.6 percent of its total exports, well below the global average of 20 percent. These figures show that product diversity in production has been lacking in the transformation to technology-oriented growth, indicating that Türkiye needs a stronger innovation-based strategy if it is to achieve its technological transformation goals.

The regional differences in Türkiye's technological development in Türkiye are also worthy of note. While strong R&D infrastructures and innovative ecosystems have emerged in provinces such as İstanbul and Ankara, many provinces in Anatolia have lagged behind in this development process. For example, 2023 figures reveal that 70.7 percent of high-tech manufacturing workplaces in Türkiye are concentrated in only five provinces and these provinces account for 76.6 percent of total employment, while 59 percent of R&D expenditures were made in İstanbul and Ankara. It can thus be understood that Türkiye's technological development has not been homogeneous at a regional level, which is something that needs to be addressed. Studies similar to the ASO Technological Development Index of Provinces (ASO-İLTEK) play a critical role in highlighting these imbalances and contribute to the development of solutions. In such a role, ASO-ILTEK gains importance as an innovative tool revealing the dimensions of the regional disparity by analysing the technological development levels of provinces in Türkiye based on detailed components.

As can be understood from an analysis of the outputs of ASO-ILTEK 2024, Ankara and İstanbul stand out clearly from Türkiye's other provinces as high-technology centers. An examination of the ASO-İLTEK 2024 findings reveals that Ankara and Istanbul stand out distinctly as high-technology provinces. This divergence can be attributed to the large number of technology development zones and R&D centers located in these provinces, the prevalence of clustering partnerships, and the relatively high number of personnel employed in high-technology sectors. As of November 2024, Ankara and İstanbul clearly stand out from other provinces in terms of technological development. Ankara hosts 13 technology development zones, 151 R&D centres, and 12 clustering organisations, while İstanbul has 16 technology development zones, 427 R&D centres and 6 clustering organisations.

ASO-ILTEK has a multi-dimensional structure, evaluating Türkiye's provinces over five sub-indexes and 37 variables, representing the inputs, outputs and facilitators of technology and innovation processes, namely: Research and Innovation Capacity, Sectoral Structure, Technological Outputs, Digital Infrastructure, Quality of Life and Labour Attractiveness. A principal components analysis was applied to the five sub-indexes to obtain the first principal component, with explained 61.4 percent of the variability in the sub-indexes. Three methods were applied to clarify the distribution of provinces in terms of their technological development levels and the average of the results was used in the following assessments.

Bilkent Cyberpark / Ankara

The main purpose of the study was to understand the disparity in the technological development of Türkiye's provinces and to create a database to guide policy development. ASO-ILTEK analyses the current situation of provinces in five key areas: digital infrastructure, research and innovation capacity, the technological level of sectoral structures, technology outputs and quality of life and labour attractiveness. Through this analysis, the index provides a holistic view of each province's economic performance, as well as its technological and social infrastructure. This approach singles ASO-ILTEK out among the other regional development indexes in Türkiye. While indexes such as SEGE measuring socio-economic development address provinces based on more general components such as demography, education and employment, ASO-ILTEK contributes to understanding how well-equipped provinces are for technological transformation by placing technology at the center.

The first part of the report presents a discussion of the transformations in the global economy and their effects on Türkiye. This is followed in the second section by an analysis of the current situation in Türkiye's technological transformation, while the third section presents the methodological framework of the ASO-ILTEK and details of the components used. In the fourth section, the main findings of the assessment of provincial technological development levels are shared through the index results and the main reasons for the regional differences are highlighted. In the final section, policy recommendations are made in the light of the findings targeting the acceleration of Türkiye's technological transformation.

As stated in the report, Ankara harbours significant opportunities for spatial, demographic and technological development on the strength of its high technology-based production and exports, its qualified human resources, its university and research capacity and its developed organised industrial zones. These characteristics, supported by a technology development model focused on product development and R&D can contribute to Ankara's emergence as an important actor in the global market.

> "ASO-ILTEK will play a key role in understanding technological disparities between provinces in Türkiye, shaping policies to bridge these gaps and turning advanced tech hubs into global players."

TRANSFORMATION OF THE GLOBAL ECONOMY

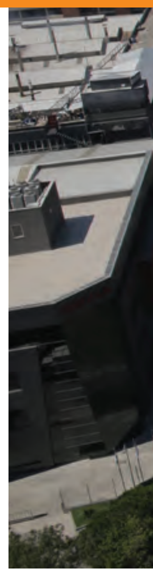
> Constantly evolving technology and innovation are accelerating the process of creative destruction, forcing ecosystem actors to adapt and transform.

The world is facing problems of various dimensions as we come to the end of the first quarter of the 21st century. While some of these problems call for solutions on a global scale, others—such as local issues and localisation trends emerging alongside globalisation—have also come to the forefront of the agenda. The first quarter of this century has witnessed an intensification of debates on the role of nation states and today it is the issue of migration and migrants that are at the centre of the discussions. Amid these debates, extremist and racist ideologies have found a place at different levels in developed and developing countries and have found support in public opinion.

The vast income inequalities between countries on a global scale are mirrored in the regional income disparities within countries. In global economy the wealth is concentrated in developed countries of the West, although broad regional inequalities can also be seen within the borders of these countries. For example, most of the wealth in the United States is concentrated in California in the west and New York in the east. These regions are also the top choice for the young, well-educated and skilled population. On a global scale, it can be said that the "Rich North" and the "Poor South" distinction is still valid.

In a general evaluation of global economies two main trends emerge. Firstly, the continuous development of technology accelerates the "creative destruction" processes described by Schumpeter and shortens product life cycles. This puts constant pressure on companies to innovate, improve productivity and transform their operations. The second trend relates to the deterioration of ecological balance around the world due to rapid industrialisation, increased carbon emissions, losses of natural balance and climate change. The first trend will be analysed in terms of its effects on the spread of digitalisation in the industry and service sectors with particular focus on the rapid development of information technologies, referred to as the "digital transformation". The second trend encompasses all the activities required for technological and economic transformation to reduce carbon emissions and is referred to as the "green transformation". The combined practices, policies and transformations associated with these two main trends are referred to as the "twin transformation".

> "The digital and green transformation known as the 'twin transformation' has now become an unavoidable reality shaping the direction of the global economy."



The actions taken within the framework of twin transformation will determine the direction of the global economy. However, there are various developments that have added to the complexity of the process in the first quarter of the 21st century. The effects of the 2008 Mortgage Crisis that devastated the US economy were felt by all economies around the world, and reduced the credibility of the global economic and financial system, leading to a questioning of the neo-liberal economic prescriptions proposed by international organisations. Although a recovery has taken place, both developed and developing economies have failed to return to their pre-crisis growth levels. The crisis, caused by excessive borrowing, speculation, and lack of regulation in the financial sector, permanently disrupted global economic balances. Since then, the world economy has been in search of a "new normal."

Since the outbreak of the COVID-19 pandemic in November 2019, global supply chains have experienced serious disruptions. As a result, the decision of developed countries to shift low value-added production to countries with cheaper labour has come under scrutiny. During the pandemic, even highly industrialised countries struggled to produce basic medical supplies such as face masks. This situation raised significant awareness about the fragility of supply chains in these countries. In the wake of these developments, the argument that strategic technologies should not only relate to defence has been strengthened with "localisation" emerging as a leading topic on the agenda, alongside the concept of "glocalisation." As such, the weakened nation-state concept also found a new space for itself. The idea of a new economic model in which globalisation and localisation meet on common ground has also gained traction in nation states, under which companies have adopted such supply chain strategies as "nearshoring", "friendshoring", and "safeshoring" as they look for ways to create more resilient supply chains.

The global economy's search for a "new normal" can also be seen in the increase in the number of political and strategic actions taken or likely to be taken in response to new situations. Although the most tangible outcome of this search process has been the twin transformation, there are certain trends that may determine the nature of the twin transformation and new global orientations.

Bursa Chamber of Commerce and Industry / Bursa

1.1. MEGATRENS

Many studies in recent years have emphasised the concept of megatrends and their contributions to the shaping of the global economy. Megatrends are large-scale changes that reshape economies, societies, and technologies and that have far-reaching long-term global impacts. Megatrends, which are usually effective for 10–15 years, radically change ways of doing business, consumer habits, and political and economic decisions around the world. The main megatrends and the developments driving them are summarised below:

- **Digital Transformational and Technological Innovations:** The digital transformation is identified as the most important megatrend in almost every report. Through the adoption of such digital technologies as robotics, 3D printers, AI, big data, cloud technologies, and the Internet of Things (IoT) by the industrial sector, production processes become more efficient, flexible, and customer-oriented. As this transformation continues to gain speed, the increasing effects of digitalisation on the workforce and processes can also be noted. According to World Bank data, the ratio of R&D expenditures to global GDP increased from 1.93 percent to 2.62 percent from 2011 to 2021, with 36 percent of the increase in R&D expenditures being attributable to the United States and 27.7 percent to China. According to a 2022 report by McKinsey & Company, the pandemic brought forward demands for digital products and services by at least 5 years, leading businesses to seek to increase their operational efficiency through investments in digital channels and automation. According to Gartner's 2023 report, the global artificial intelligence software market has reached USD 62 billion, while the 2024 Ericsson Mobility Report states that the number of 5G subscribers reached 1.7 billion in the first quarter of 2024, and is set to reach 5.6 billion by 2029, leading to the proliferation of IoT devices and autonomous systems with high-speed and low-latency connections. All the above data support the thesis that new technologies are rapidly penetrating the global economy.

- **Sustainability:** Climate change, green energy transformation, and resource efficiency are among the most prominent megatrends. Companies must take strategic steps to reduce their carbon emissions and switch to sustainable business models. The Fujitsu and Oxford Economics' Global Sustainability Transformation Survey 2023 report emphasises that sustainability goals have become one of the top priorities of the business world. Companies use digital technologies to reduce carbon emissions and to switch to sustainable production models. Among the 1,800 companies surveyed, 34 percent said that sustainability was among their top three priorities, while 80 percent placed it in the top five. The sustainability trend is also bringing about changes in the field of finance. For example, there has been a significant increase in the value of green bonds issued worldwide over the last few years. According to Climate Bonds Initiative data, the USD 37 billion value of green bonds issued in 2014 has risen to USD 564 billion as an average of the 2021–2023 period. According to Morgan Stanley data, the value of assets under the management of sustainable funds increased by 134 percent from 2018 to 2023, reaching USD 3.4 trillion.

> “Megatrends such as the Digital Transformation and Technological Innovations, Sustainability, Demographic Changes and the Evolution of Global Trade are forcing economies and societies to change and transform and within this transformation, the density of the innovative class will be one of the main determining factors.”

- **Demographic Changes:** The global population growth, ageing, migration and changes in education levels are all part of another megatrend that is radically changing labour markets and economic structures. Demographic changes are both increasing the labour shortages in developed economies due to the ageing population and transforming labour dynamics in emerging economies due to the increase in the young population. The United Nations (UN) estimates that the global population will grow from 8.1 billion in 2023 to 9.7 billion in 2050, with 99.1 percent of this population growth expected in today's lower-middle or low-income economies. The median age forecast for 2050 is 44.5 years for high-income economies and 44.8 years for upper-middle-income economies, which is one of the factors triggering the tendency of these economies to turn to technology for productivity growth.
- **The Evolution of Global Trade:** Trade wars, geopolitical tensions and supply chain vulnerabilities are all contributing to the reshaping of global trade. The 2019 ESPAS report claims that global trade has evolved into an Asia-centred structure, and suggests that this trend will change the balance of power in the global economy in the long term. China, as the most prominent country in the rapid period of globalisation, has not only increased its weight in global trade, but has also become a global production centre that creates its own value chains and an innovation centre in the creation of disruptive technologies.

According to research by Roland Berger, 49 percent of patents in frontier technologies in the field of Industry 4.0 and 56 percent of patents in green and renewable technologies in the 2000–2021 period were of Chinese origin. Furthermore, the 3.6 percent of total global GDP and 3.8 percent of goods exports attributable to China in 2000 had risen to 16.9 percent and 14.1 percent, respectively, by 2023, while its share of global R&D expenditures rose from 1.56 percent in 2000 to 17 percent in 2021.

These megatrends are consistently highlighted across various studies and are considered key drivers shaping the future of the global economy. In addition to digital transformation, sustainability and demographic change, the evolution of global trade is also a major component of these trends.

These megatrends, triggered by technologies and innovation, have become key contributors to economic growth and competitiveness. The green transformation and green technologies are key factors in sustainable growth, while the digital transformation increases the operational efficiency of businesses, reduces costs, and drives the creation of new business models. Today, economic development continues in accordance with the aforementioned trends along the following four axes:

- **Productivity and Innovation:** According to OECD data, digital technologies increase the productivity of businesses by 20 percent on average, with automation and AI-based solutions in particular increasing productivity through the reduction of human error.
- **New Business Models and Sectors:** New business models, such as the platform economy, the sharing economy and the gig economy, have emerged, with companies such as Uber, Airbnb and Amazon reaching multi-billion dollar valuations through the transformation of traditional industries..

- **Global Connectedness:** Digital technologies have facilitated cross-border trade and fostered the development of global supply chains. The World Trade Organisation (WTO) predicted that the share of e-commerce in global trade would reach 15 percent by 2022.
- **The Rise of Innovative Industries:** Technology-oriented sectors such as fintech, biotech and cleantech are witnessing rapid growth. According to the 2022 KPMG report, global fintech investments have reached USD 210 billion.

1.2. ASYMMETRIC TRANSFORMATION

All these developments suggest that the global economy has entered a period of transformation that can be expected to continue rapidly. Countries and companies can either lead, adapt, or resist this transformation. Leading means adopting innovative processes and creating new business models; keeping pace requires adaptation to existing transformation processes; and resistance means sticking to old business models and developing a resistance to transformation, which increases the risk of failure in the long term.

The World Bank's 2024 World Development Report highlighted the struggles of countries in their efforts to escape the middle-income trap, being the slowdown in growth rates experienced by many countries after reaching the middle-income level and the difficulties they face in transitioning to a high-income economy. According to the report, demographic pressures, rising debt burdens, and slow productivity growth hinder countries in their efforts to escape from this trap. Traditional development strategies, especially capital investments, are less effective in middle-income countries, and so it is suggested that countries adopt more innovative strategies to sustain growth.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> "The 2024 World Development Report emphasises that exiting the middle-income trap is possible through the 3i strategy,* namely investment, technology integration and innovation."
>
> *investment, infusion, innovation

The report goes on to advise countries to adopt a so-called "3i strategy" (investment, infusion, innovation) to escape the middle income trap:

- **Investment:** Low-income countries accelerate growth initially by increasing capital investment.
- **Technology Integration (Infusion):** Once middle-income status is reached, global technologies are needed for integration into the local economies.
- **Innovation:** Focusing on innovation and developing new technologies becomes critical for countries seeking to advance to a high-income economy.

The 2024 World Development Report also addresses the concept of creative destruction, identifying it as a key mechanism for overcoming the middle-income trap. The report defines creative destruction as the destruction of old economic structures—industries, labour, technologies—and their replacement with more innovative and efficient models. Digitalisation and automation are two of the strongest examples of creative destruction. Digital technologies facilitate the emergence of new and more efficient models by eliminating traditional business models. For example, automation in production processes reduces the demand for labour, with machines taking on roles that were previously done manually. Creative destruction also leads to the emergence of new business models, such as the gig economy and the sharing economy. Platforms such as Uber and Airbnb have brought a new dynamism to the market through their transformation of traditional business models. In this process, old business models are weakening, while innovative initiatives are gaining stronger positions in the global economy.

> In the field of global border technologies, the United States and China lead the field with shares of patents amounting to approximately 70 percent, while the United States, Sweden, Singapore, Switzerland and the Netherlands are at the top of the global readiness table in this field.

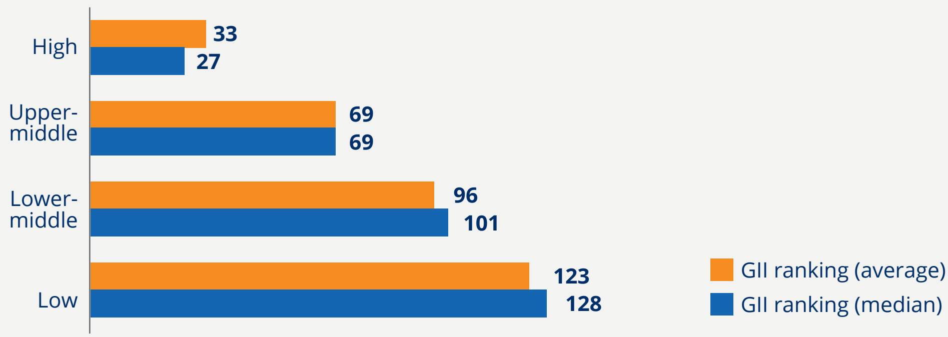
The World Development Report found the number of innovative enterprises to be low in middle-income countries, where large companies do not innovate sufficiently, and this is clearly apparent in the Turkish case. According to İstanbul Chamber of Industry data, 265 of Türkiye's 500 largest industrial enterprises were engaged in R&D activities in 2023, although the ratio of expenditures on these activities to their total sales from production was only 0.48 percent. The World Development Report states further that creative destruction increases the competitiveness of economies by bringing them closer to the global technology frontier. In many middle-income countries, however, incumbents resist such disruptions in a bid to maintain their market dominance, which hinders innovation and economic dynamism. To overcome this situation, the report recommends that countries should remove regulations that support the preservation of old, inefficient structures and create a more competitive economic environment. In sum, the report highlights the low capacity of middle-income countries to adapt to innovation when compared to high-income countries, identifying this issue as one of the main reasons they become stuck in the middle-income trap. This further supports the thesis that significant differences exist between countries in terms of their levels of preparation for the new economy, leading the process to proceed asymmetrically in different income groups.

1. The gig economy is a working model in which short-term, flexible and project-based works are carried out through digital platforms, where workers earn an income from temporary jobs sourced through various platforms, rather than entering into aa full-time employment relationship with employers.

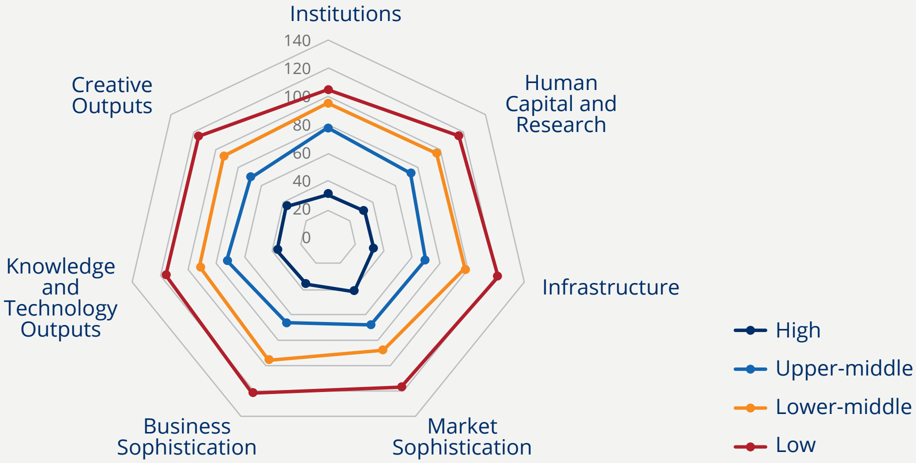
The differences between the scales used to measure levels of readiness for the new economy are also reflected in country-level index studies. The Global Innovation Index (GII) announced by the World Intellectual Property Organisation (WIPO) assesses innovation as an engine of economic and social progress. The Index comprehensively measures country innovation ecosystems and analyses the socio-economic impacts of scientific investments, technological progress, technology adoption rates and innovation. Of the 133 countries with calculated index scores, 51 can be considered high income, 34 as upper-middle income, 38 as lower-middle income and 10 as low income. In the 2024 index country rankings by income group, the high-income group is 32.7, the upper-middle income group is 69.2, the lower-middle income group is 96.4 and the low-income group is 122.9. When the sub-index is analysed in detail, it is worthy of note that the areas in which the difference between the high-income economies and upper-middle-income economies in terms of innovation potential is most prominent are institutions, human capital and research and infrastructure (Figure 1).

Figure 1. GII 2024 ranks (by income group)

GII ranking of countries by income groups (2024)



Average ranking of income groups in GII sub-indexes (2024)

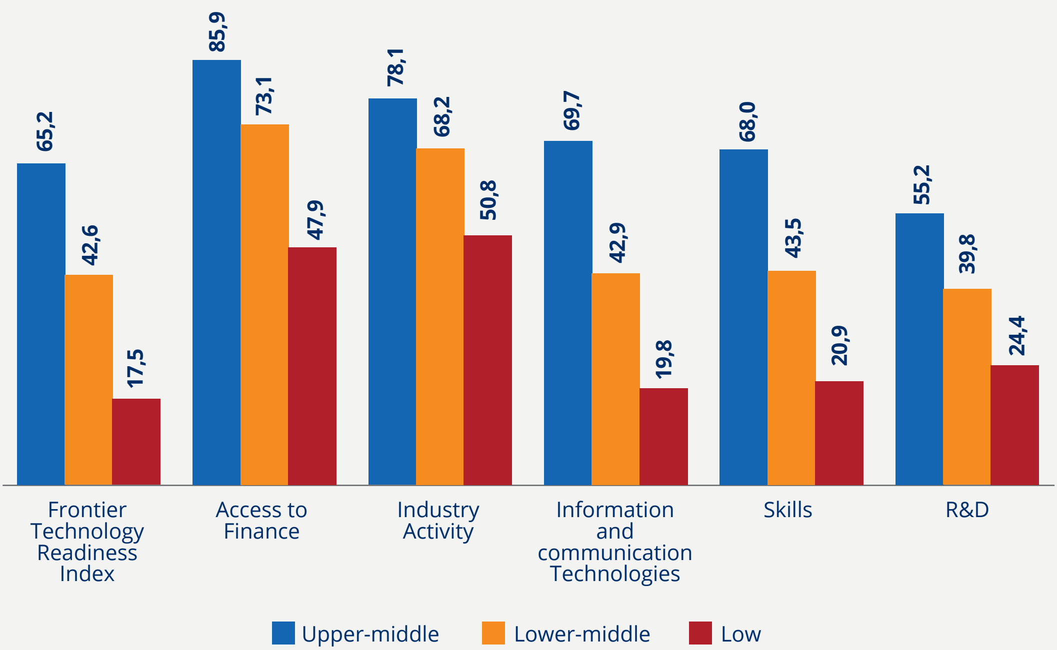


Source: WIPO.

UNCTAD's Frontier Technologies Readiness Index (FTRI) also points to a similar situation. The FTRI was created to assess the level of readiness of countries for Industry 4.0 and frontier technologies based on the measurement of the capacity of countries to adopt, adapt and make use of innovative technologies, as well as their scientific infrastructure, digitalisation level and labour skills.

The index, analysing the readiness levels of countries in areas such as digital infrastructure, research and development capacity, industrial capacity, access to finance and skills, was calculated for 166 countries, 53 of which are high income, 44 upper-middle income, 51 lower-middle income and 18 low income. The ratio of income group averages to the average of high-income countries for the overall index and its components is presented in Figure 2. As can be seen, while there are relatively low differences between income groups in terms of their access to finance and industrial activity, the gap widens for information and communication technologies, skills and R&D. Although the United States, Sweden, Singapore, Switzerland and the Netherlands rank highest in terms of readiness for frontier technologies, the United States and China continue to lead globally, holding around 70 percent of all patents related to frontier technologies.

Figure 2. Ratio of Average UNCTAD-FTRI Score to Average of High Income Countries (%, 2021)

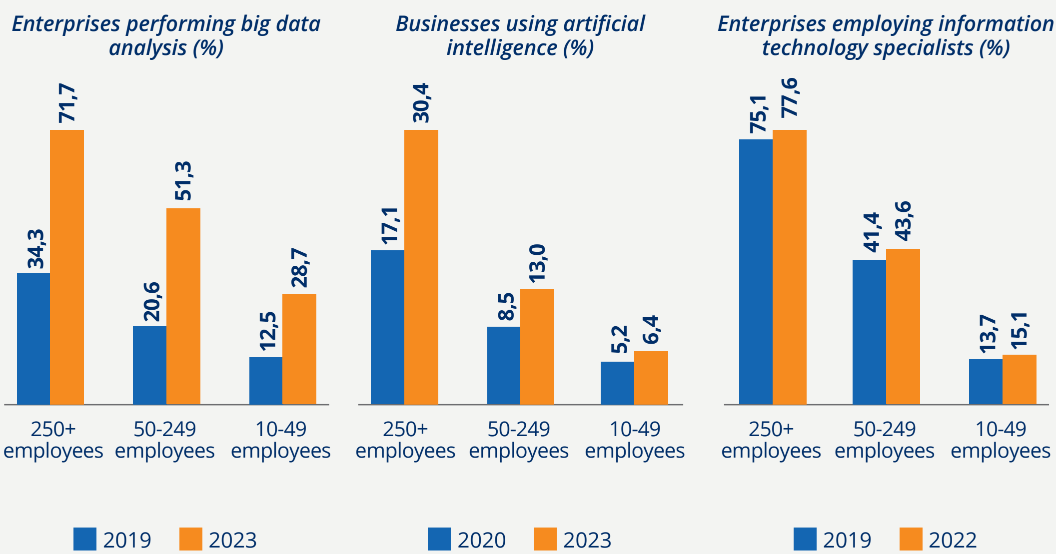


Source: UNCTAD.

Adapting to change is not as easy for companies as it is for countries. Differences in infrastructure and human capital between countries also stand out among enterprises and especially among enterprise scale groups. As can be seen in Figure 3, when the averages of the 27 European Union (EU) member states are analysed, significant differences can be seen between small, medium and large-scale enterprises in terms of both their adoption of technologies and their access to human resources that can use these technologies. For example, by 2023, 71.7 percent of the large-scale enterprises across the European Union had carried out big data analyses and 30.4 percent were using artificial intelligence, while these figures were 28.7 percent and 6.4 percent for small-scale enterprises, respectively. Similarly, according to 2022 data, 77.6 percent of the European Union's large-scale enterprises employed IT specialists, while the rate was 15.1 percent among small-scale enterprises.

> In the EU member states, there are significant differences between SMEs and large enterprises in their employment of big data analysis, artificial intelligence and information technologies specialists.

Figure 3. Ratio of enterprises with selected competences in EU-27 to total enterprises



Source: OECD.

Also worthy of note are the differences in the speed of adoption of technologies. While the share of enterprises using AI in the total number of enterprises using artificial intelligence across the European Union increased by 13.3 points in large-scale enterprises from 2020 to 2023, this increase was limited to 4.5 points in medium-sized enterprises and 1.2 points in small-sized enterprises. Large-scale enterprises differ significantly from small and medium-sized enterprises in terms of both their level and speed of preparation. This may be due to sectoral differences between scales, but may also be related to the fact that larger companies allocate more resources to digital transformation processes.

Kocaeli University Technopark / Kocaeli

1.3. THE RISE OF NEW INDUSTRIAL POLICIES

Industrial policies are government interventions that take the form of incentives and regulations applied to certain sectors aimed at accelerating economic growth, supporting strategic sectors and gaining an advantage in global competition. In the 20th century, developing countries in particular underwent rapid industrialisation following

the implementation of industrial policies. While the free market policies of the 1980s and 1990s and the Washington Consensus led to a decline in interest in such policies, they have returned to the agenda in recent years. Among the reasons for the resurgence of industrial policy are the disruptions in global supply chains, the increased competition in trade and technology between countries, the efforts to combat climate change and the demand for increased economic resilience (Velloso and Artecona, 2022; Evenett et al., 2024). Moreover, the severe impacts of the COVID-19 pandemic increased the importance of local production and supply chain resilience (Liu, Li, & Du, 2023). All of the above have compelled countries to re-evaluate their growth strategies and to initiate efforts to establish a more robust industrial infrastructure. Aiginger and Rodrik (2020) argue that success stories such as China's industrialisation, backed by intensive state support, have led to the resurgence of the importance of industrial policies.

Global megatrends, such as the green and digital transformations are at the centre of new industrial policies and major economies such as the European Union, the United States and China are seeking to increase their strategic autonomy through large-scale investments in sectors such as renewable energy, AI, 5G and high-tech. This has imposed a more entrepreneurial role on governments, not only to address market failures but also to create new markets.

Traditional industrial policy generally seeks to develop domestic industries through state subsidies of certain sectors or protective trade policies. Such policies have been based largely on inward-looking economic models with industrial import substitution policies, especially in Latin America, seeking to encourage domestic production by limiting foreign competition. The new industrial policy approaches are more outward-looking and strategic, encouraging integration into the global value chains and export-oriented growth.

Moreover, unlike traditional policies, the new industrial policies address such social and environmental objectives as sustainability, reduced inequality and green growth, while also supporting innovation. For example, policies such as "Build Back Better" and the "CHIPS Act" in the United States aim to support semiconductor manufacturing and technological innovation, while the EU Green Deal and the US Inflation Reduction Act are large-scale industrial policies that aim not only to stimulate economic growth but also to ensure environmental sustainability. (Juhasz, Lane and Rodrik, 2023) In China, industrial policies are being reshaped within the framework of comprehensive development plans targeting an increase in regional development and productivity (Liu, Li and Du., 2023). To summarise, new generation industrial policies go beyond the classical intervention methods with more comprehensive strategies, the most prominent features of which are as follows:

- **Mission Orientation and Social Goals:** Developed and developing countries aim to create social impact through the harmonisation of industrial policies with social, environmental and economic objectives. For example, the European Union, the United States and many developing countries are reshaping their industrial policies to align with green transformation and sustainable development goals (Chang and Andreoni, 2020; Soete and Stierna, 2023).

- **Sustainability:** Climate change and environmental crises are at the centre of new industrial policies, which target not only economic growth but also environmental sustainability and reduced carbon emissions.

- **Promoting Digital and Technological Innovation:** The technological innovations and digitalisation that triggered the reshaping of the global economy have become central to industrial policies. States are seeking to create new business models and industries by increasing investments in this field. New regulations and incentives are being implemented, especially in the fields of AI, automation and digital supply chains, with support provided for the transition to digital technologies (Andreoni et al., 2021; Mazzucato et al., 2020).

- **Regional and Local Approaches:** Instead of single country or centralised policies, "locally oriented" industrial policies that prioritise local resources and potential are becoming more widespread. Particularly in Europe, the Schumpeterian perspective emphasises the development of regional innovation and local capacities (Bailey, Pitelis and Tomlinson, 2023; Soete and Stierna, 2023).

Eskişehir Technopark / Eskişehir

- **The Entrepreneurial Role of the State:** As Mariana Mazzucato (2013) describes, the state no longer only corrects market failures, but also takes on an entrepreneurial role in the creation of new markets. The investor role of the state has increased, especially in the fields of green energy, high-tech and digital transformation.
- **Geopolitical Competition:** The increasing competition between such global powers as China and the United States has increased state interventions in strategic sectors, with interventionist approaches being more prominent in such strategic areas as semiconductors, renewable energy and technology.

Juhasz and Lane (2024) argue that industrial policies have considerable potential, especially in middle- and low-income countries, but are hindered by a lack of government capacity and political constraints. Particularly in the case of Thailand, the lack of bureaucratic capacity and the political will necessary for the successful implementation of industrial policies prevented the success of industrial policies in the 1970s, however, the changing political environment in the 1980s led to a significant improvement in Thailand's industrial policy.

As can be understood from all the above, maintaining a strong position in the global economy as it transitions to a new era requires both states and companies to fulfil their duties. As much as the transformation itself, the increasing intensity of industrial policies as they re-emerge and take on a new identity in support of the adaptation to this transformation is forcing states to take faster action. It is therefore important for emerging economies like Türkiye to analyse their competencies, their positions in the global economy and their potential, and to take rapid action to realise their potential.


2

AT WHAT STAGE IS TÜRKİYE IN ITS TECHNOLOGICAL TRANSFORMATION?

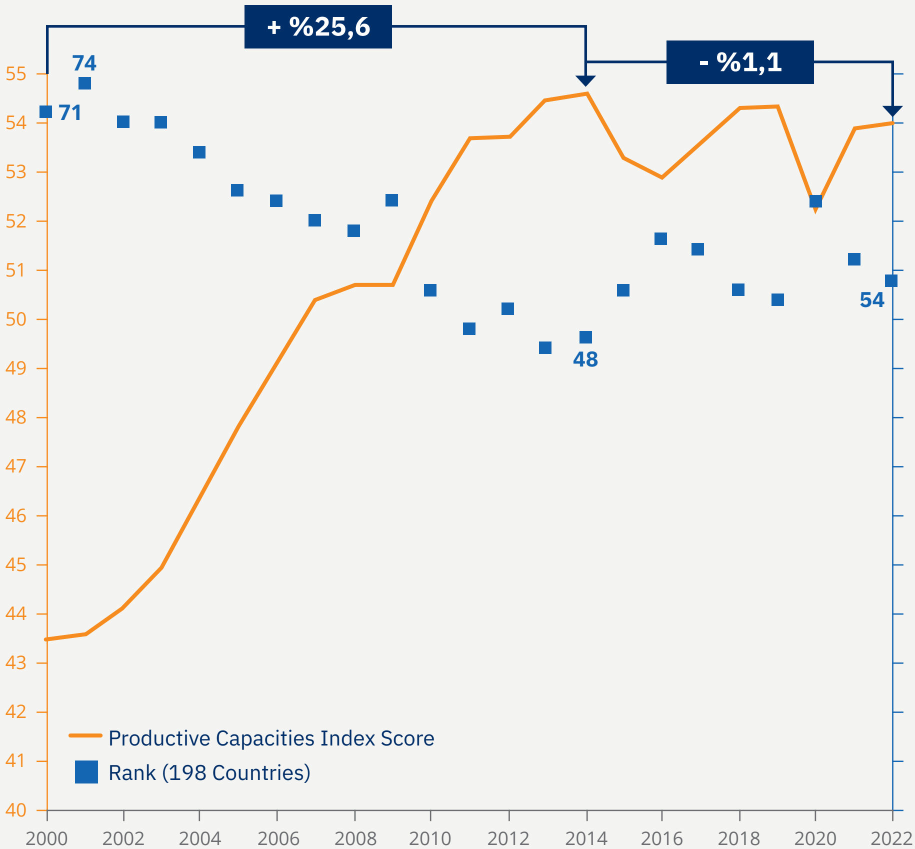
> In Türkiye, 70.7 percent of the country's high-tech manufacturing workplaces are concentrated in only five provinces and the share of these provinces in total employment is 76.6 percent.

According to UNCTAD's Productive Capacities Index (PCI), Türkiye has been experiencing difficulties in increasing its productive capacity since 2014. The country increased its productive capacity score by 25.6 percent in the 2000–2014 period, carrying it up 23 places in the global ranking of 198 countries. However, this was followed by a 1.1 percent decline in the index score between 2014 and 2022, along with a drop of six places in the global ranking (Figure 4). An analysis of the components of the index reveals an average or below average performance in all components other than structural change, which includes such variables as diversity and quality of exports, the ratio of gross fixed capital investments to national income, and the share of industry and services in the national income.

Türkiye is among the countries with the highest product and market diversity in its exports. Türkiye has ranked sixth in the world since 2019 in terms of the number of competitively exported products, and has been the global leader since 2010 in terms of market diversity, based on the number of countries to which exports are intensively exported (Cunedioğlu, 2024). Although the country's high product diversity suggests that there are opportunities to specialise in new and niche areas of activity that can increase growth potential, Türkiye has long struggled to take advantage of this potential.

Figure 4. UNCTAD Productive Capacities Index and Türkiye's Performance

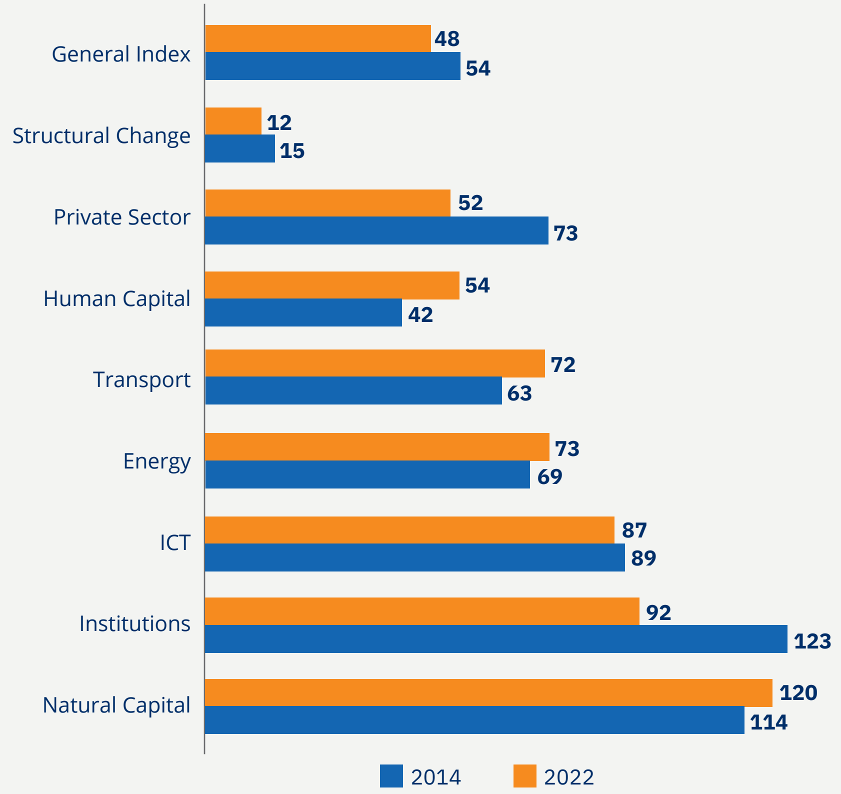
Türkiye's Performance in the Productive Capacities Index



Source: UNCTAD.

The content of national policy documents, the awareness of the central government and increase production's technology intensity reveal these to be a priority target for Türkiye. Encouraging the production of high value-added and technological products and ensuring the digital transformation of industry are among the main targets defined in the last two development plans. Similarly, the 2023 Industry and Technology Strategy emphasises the development of domestic and national technologies, increased R&D and innovation and support for technology-based entrepreneurship, but despite this, the share of technology-intensive sectors in Türkiye's exports and total value added is still low. According to World Bank data, 19.1 percent of global exports of goods in 2022 were realised by the high-tech sectors, while this ratio was 3.6 percent for Türkiye. Similarly, the share of medium and high technology sectors in total manufacturing value added in Türkiye was 34.3 percent in 2021, earning it a global ranking of 14, while the average of the countries ranked in the top 13 was 45.4 percent.

Türkiye's Ranking in the Productive Capacities Index and its Components (2014 and 2022, 198 Countries)



> While Türkiye has made significant progress in terms of the product and market diversification in its exports, it has been unable to increase the share of medium and high-tech in production to the targeted extent.

To improve this situation, targets such as increasing the ratio of R&D expenditures to national income and developing qualified human resources have been set in different policy documents. Moreover, action plans prepared by the Coordination Board for Improvement of the Investment Environment (YOİKK) detail the steps to be taken to attract technology-intensive investments and to raise the technology level of domestic production.

An analysis of Türkiye's technology ecosystem reveals that the potential in the fields of entrepreneurship and innovation has yet to be fully exploited. TÜBİTAK's 2024–2028 Strategic Plan states that private sector and university cooperation should be strengthened to increase R&D and innovation activities. In addition, increasing the effectiveness of technology transfer offices and technoparks and supporting the commercialisation processes of enterprises are also important.

In conclusion, if Türkiye is to increase its production capacity and technological intensity, it must meet the targets set out in policy documents. Providing support for export diversification in the production and export of advanced technologies will make it possible to achieve sustainable economic growth. As such, there is a need to ensure both effective implementation and a focus on the right problem areas. This section of the report aims to identify the existing problems hindering Türkiye's technological transformation and development. To this end, first, the current level of knowledge required to facilitate the transformation is evaluated, after which, Türkiye's performance against different global technological development indexes is analysed. Finally, the current provincial asymmetry in the ongoing technological transformation is discussed.


ASO Model Factory / Ankara

2.1. KNOWLEDGE INTENSITY REQUIRED FOR TECHNOLOGICAL TRANSFORMATION

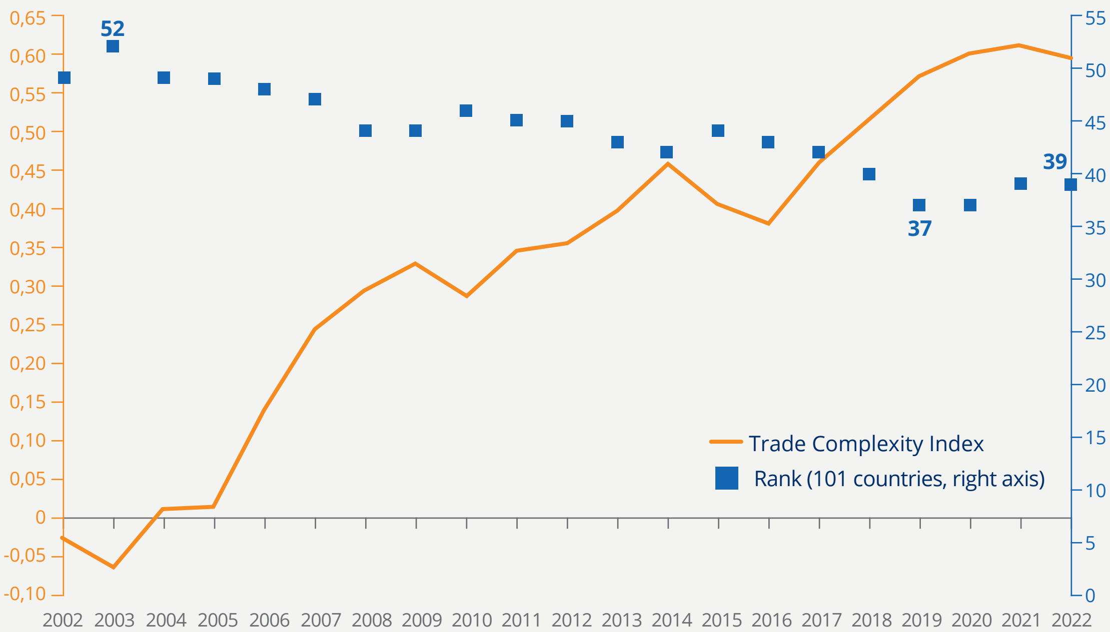
Stojkoski et al. (2023) emphasise that although traditional measures of economic complexity are often based on trade data, these measures may overlook important factors like innovation. To address this shortcoming, studies have expanded the economic complexity indicators to include innovation, with such data as patent applications and research publications. These studies have also examined whether these expanded complexity measurements can better explain inclusive green growth. Three economic complexity indicators have been developed for this purpose: Trade, technology and research.

Among these three indicators, the "Trade Complexity Index (ECI trade)" measures the complexity of a country's trade activities based on the diversity and sophistication of the products it exports. Countries exporting a wider range of advanced products have higher trade complexity. This indicator is often used to predict economic growth and income inequality. More complex economies generally lead to faster growth and a more equitable distribution of income. According to this variable, Türkiye ranked 39th among 101 countries with uninterrupted data for the 2002–2022 period. In terms of production-oriented knowledge intensity implied by the trade structure, Türkiye was ranked 52nd in 2003 and improved to 37th in 2019. However, due to the impact of the pandemic, the ranking has since stagnated (Figure 5).

> "Although Türkiye has significant technological potential, it cannot be fully exploited due to regional inequalities and its limited technology-intensive production."

Patent density is one of the most obvious indicators of a country's innovation tendency. The ECI Technology Complexity Index (ECI Technology) measures the innovation intensity and sophistication of a country's technology sector based on its patent applications. Countries with high technological sophistication rates have the capacity to produce more high technological innovations. When trade complexity is also taken into account, this indicator can play an important role in predicting economic growth. On a list of 70 countries for which uninterrupted data is available for 2002–2021 assessing technological complexity, Türkiye increased its rank from 29th in 2004 to a peak 8th position in 2021, which can be attributed to the orientation of patent activities towards more qualified fields than the global average. When it comes to technological transformation, however, it should not be forgotten that only a few large economies play significant roles in the creation of disruptive or emerging technologies. According to Roland Berger (2023), China and the United States accounted for 67% of frontier technology patents focused on Industry 4.0, 65% of those in green and renewable energy frontier technologies, and 67% of patents in other frontier technologies during the period 2000–2021. However, in the Technology Complexity Index ranking, these two countries were placed 29th and 25th, respectively. In this regard, it would not be wrong to say that Türkiye has been successful in encouraging patent and research activities in qualified areas in which the impact is clearly visible, but not in areas that require risk, and in which the impact is not clear. On the other hand, in WIPO's GII 2024 study, Türkiye ranked 25th among 133 countries in terms of patent applications in proportion to its economic size, and 32nd in terms of international patent applications.

Figure 5. Türkiye's Trade Complexity Index Ranking



Source: Observatory of Economic Complexity

The ECI Research Complexity Index (ECI Research) measures the complexity of a country's research output on the basis of published academic papers. Research complexity is an important indicator in the sophistication of economies, although Stojkoski et al. (2023) states that this indicator is less effective in predicting economic growth and income inequality, suggesting that it plays a more important role in explaining the green economy. While Türkiye ranked 21st among the 101 countries with available data in this index in 2004, it dropped to 24th place in 2022.

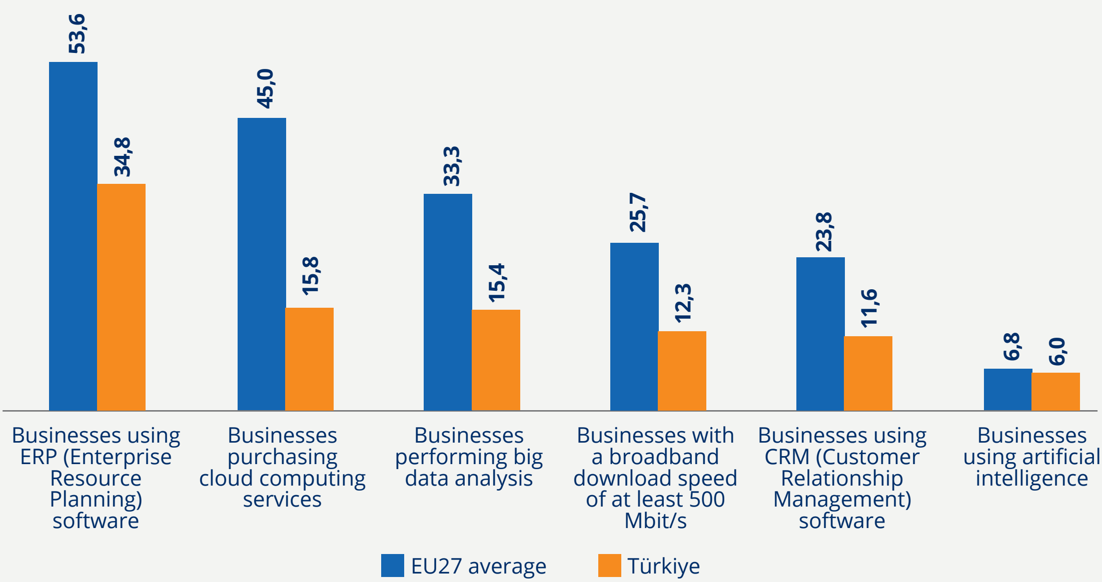
> "The fact that Türkiye ranks 25th in the world in patent applications in proportion to its economic size reveals that innovation efforts have gained increased momentum."

Complexity indicators suggest that Türkiye has a low production-oriented knowledge intensity, implied by its sectoral structure, but an above-average innovation tendency. On the other hand, the extent to which an economy adopts emerging technologies is as important an indicator of its level of readiness for technological transformation as the intensity of its production knowledge. Although the use of AI in the manufacturing sector in Türkiye seems to be close to the EU average, the gap is widening in the average of all sectors. The rate of use of artificial intelligence in the "professional, scientific and technical activities" sector is 6.6 percent in Türkiye, compared to the 18.5 percent EU average in 2023, (Figure 6). Accommodation and food services and administrative and support services are other sectors in which Türkiye is lagging behind the EU average in terms of their use of artificial intelligence. When analysed on a scale basis, the difference in use of AI between the European Union and Türkiye is 1.4 points for small-scale enterprises, 6.6 points for medium-scale enterprises and 11.9 points for large-scale enterprises.

In areas of technology utilisation other than AI, Türkiye lags far behind the EU average. For example, internet speed, as an indicator of the development and effective utilisation potential of technologies continues to be a major problem in Türkiye. According to OECD data, as of 2023, enterprises with broadband download speeds of at least 500 Mbit/s accounted for 12.3 percent of all enterprises in Türkiye, compared to an average of 25.7 percent across the EU-27 (Figure 6). According to Speedtest data for August 2024, Türkiye ranks 106th out of 161 countries with a fixed broadband download speed of 42.9 Mbit/s. Furthermore, Türkiye ranks 21st among the 24 countries on the IMF's list of emerging economies in terms of fixed broadband internet speed. The average fixed broadband download speed in emerging economies is 139.3 Mbit/s in the Americas, 138 Mbit/s in Europe, 99.4 Mbit/s in Asia and 38.5 Mbit/s in Africa.

> "Türkiye ranked 37th among 133 countries in the 2024 Global Innovation Index, revealing it to be relatively effective in innovation outputs."

Figure 6. Ratio of enterprises with selected competences to total enterprises in the EU-27 and Türkiye (%, 2023)



*Source: OECD. * Percentage of manufacturing enterprises with 10+ employees.*

2.2. TÜRKIYE'S POSITION AMONGST TECHNOLOGICAL DEVELOPMENT INDICATORS

Although Türkiye lacks the necessary knowledge intensity required for its technological transformation, the ideal tools for assessing the country's level of technological development are composite indexes, which allow global comparisons. These indexes provide a better understanding of strengths and weaknesses by comparing the technology and innovation capacities of countries at an international level. While there are many indicators that serve this purpose, this section of the study focuses on three of the most important: WIPO's Global Innovation Index (GII), UNCTAD's Frontier Technology Readiness Index (FTRI) and the Descartes Institute's Future Readiness Economic Index (FREI).

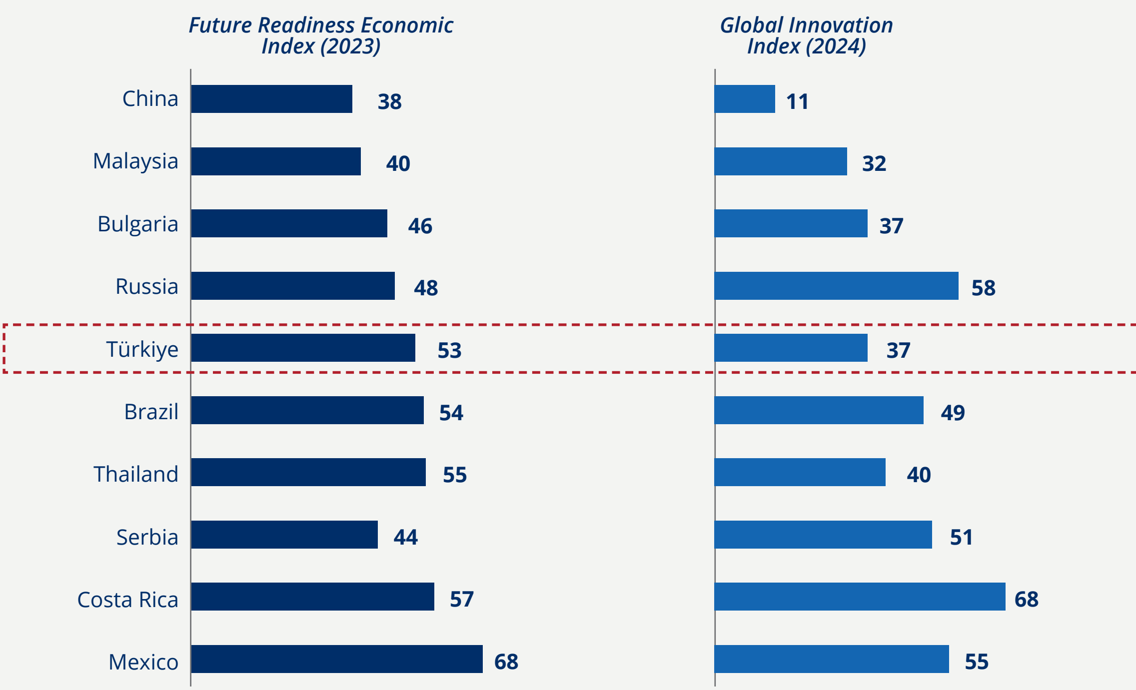
The GII, which evaluates the innovation capacities and outputs of countries, addresses innovation performance based on a wide range of factors, such as institutions, human capital, infrastructure, market sophistication and knowledge production. It monitors how well innovation investments are translated into tangible results in the form of patents, technology exports, etc., considering innovation as a driver of economic growth. The index differs from other indexes in its analyses of innovation clusters on a province basis. In the GII results for 2024, Türkiye was ranked 37th among 133 countries in the general index results. While on the list of the top 100 science and technology clusters, İstanbul and Ankara ranked 59 and 86, respectively. Based on the GII results, Türkiye is considered an efficient country with a high innovation output compared to the innovation input classification.

The FTRI published by UNCTAD assesses the readiness of countries for the adoption of frontier technologies such as AI, IoT and green hydrogen, and focuses in particular on how technological capacity is aligned with opportunities for sustainable development and the green transformation. Unlike the GII, the FTRI index focuses on the ability of countries to cope with future technological challenges rather than their innovation levels. In the most recent FTRI general index data, from 2021, Türkiye ranks 53rd out of 166 countries. Türkiye's overall index score is 62 percent that of the top ranking United States. Compared to both the most successful country in the sub-index and the United States, which ranks first in the overall index, Türkiye's performance in the "skills" is the area has declined the most.

The FREI, published by the Descartes Institute, assesses the readiness of countries for the future based on four main pillars: Physical capital, human capital, technology and competitiveness. The FREI attaches considerable importance to digital transformation. It covers topics such as digital infrastructure, cyber security, AI regulations and digital policy frameworks. What makes this index unique is its focus on future competitiveness through digital technologies, as well as on digital governance and policies. According to the FREI 2023 results, Türkiye ranks 53rd among 124 countries. When Türkiye's performance at the sub-index levels is analysed, it can be seen to perform weakest in the field of "human capital" concurring with the FTRI results.

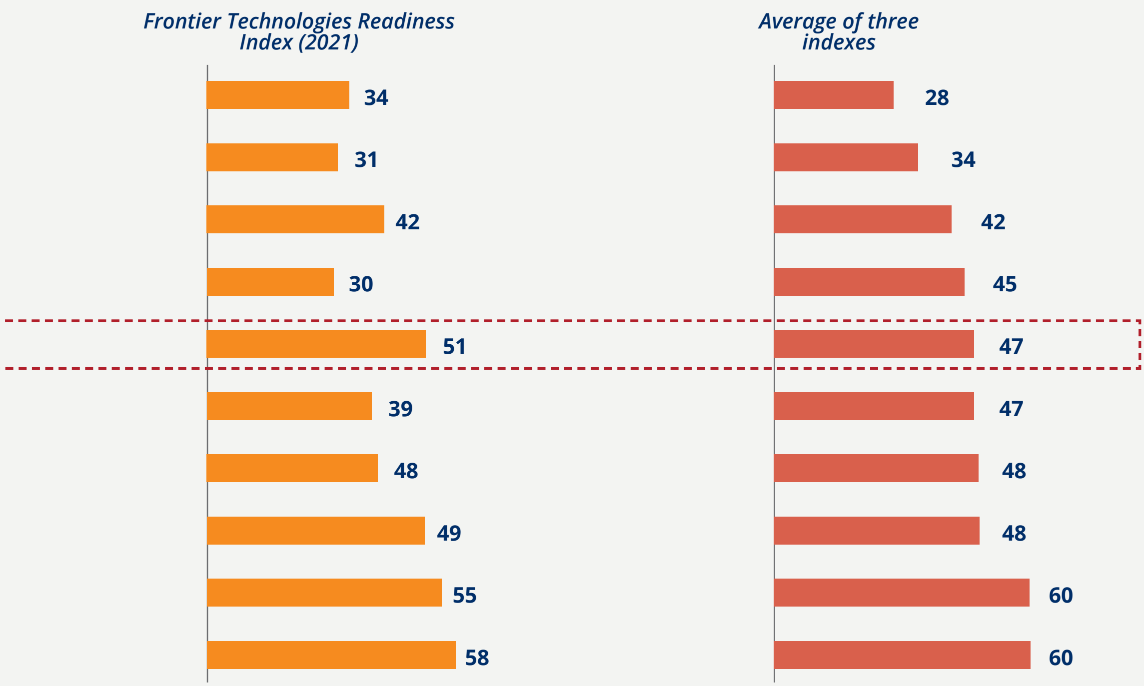
The three indexes differ in terms of their scope and focus. While the GII provides a broader perspective of innovation inputs and outputs, UNCTAD's index takes a more specific approach, in assessing sustainable development and readiness for frontier technologies. The FREI, on the other hand, focuses more on the competitiveness of countries based on their digitalisation levels and future-oriented policies. Each provides a comprehensive view of the technological development and innovation of nations, revealing different dimensions of their technological capabilities and readiness. With this in mind, an approach that evaluates all three indexes together has been adopted for the analysis of Türkiye's level of readiness for the technological transformation.

Figure 7. Rankings of upper-middle income countries in selected technological development



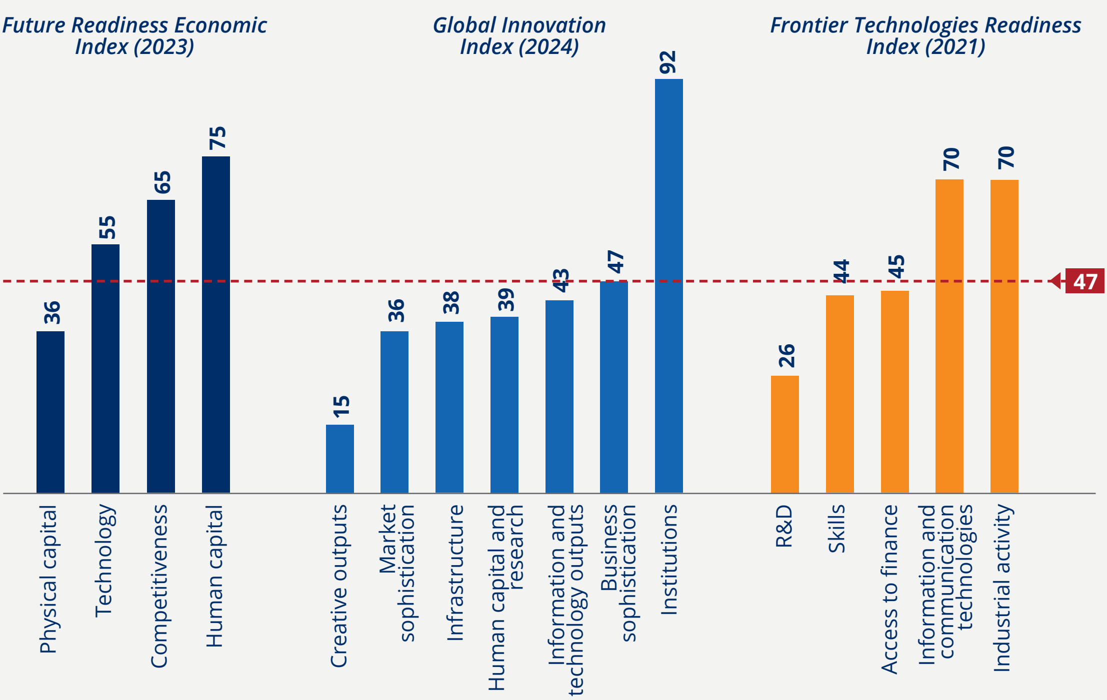
*Source: UNCTAD, Descartes Institute, WIPO. *10 countries with the highest average three-index rankings among the 121 upper-middle-income countries with data in all three indexes.*

The 121 countries with available data across all three studies were re-ranked based on the results of the three overall indices, and the averages of these rankings were taken into account. According to this average ranking indicator, Türkiye ranks fifth among the top 10 upper-middle-income countries, while its average overall ranking is 47. China and Malaysia stand out from the other upper–middle-income countries that outperform Türkiye in all three indexes. Bulgaria and Russia outperform Türkiye in FREI and FTRI, but lag behind Türkiye in GII.



Türkiye's rankings among 121 countries in the sub-indexes of the three indexes are presented in Figure 8, identifying its strengths and weaknesses in terms of technological sophistication and readiness for transformation. The average of Türkiye's overall index rankings in the three studies were used as a threshold, calculated as 47. In three of the components FREI (technology, competitiveness and human capital) Türkiye performed below the overall average, except in the physical capital component. Türkiye's performance in the GII rankings was weakest in the institutions component, but it ranked 15th in the innovation outputs component among the countries active in the field of innovation. In the FTRI, Türkiye lags behind the general average in the information and communication technologies and industrial activity components, but performs above-average in the R&D component.

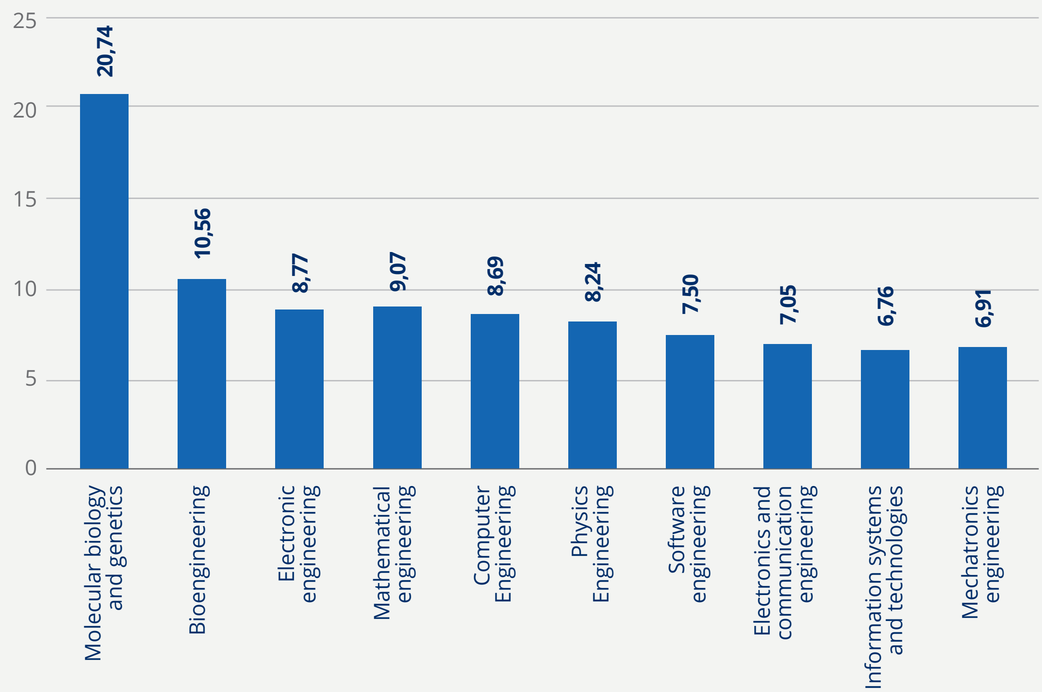
Figure 8. Ranking of Türkiye in Technological Development Sub-index Indexes (121 Countries)



Source: UNCTAD, Descartes Institute, WIPO.

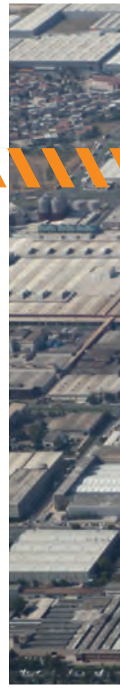
One of the leading issues contributing to Türkiye's low ranking in the skills component revealed by the international indicators is talent migration. The TÜİK data presented in Figure 9 indicate that a significant portion of the qualified human capital graduating from the country's leading technology-related fields has migrated abroad. In fields directly related to technological transformation, such as electrical-electronics and computer engineering, this rate is around 9 percent, while in fields like genetics and bioengineering, which contribute to the biotechnology sector, it exceeds 10 percent.. The human resources migrating abroad are, in fact, those with qualifications that every country is seeking. This reveals the difficulties Türkiye faces in retaining its talents and attracting new ones. INSEAD's Global Talent Competitiveness Index also highlights this risk: according to the index results, Türkiye ranks 81st among 134 countries in retaining talent and 107th in attracting new talent. These data clearly demonstrate the need for stronger and more comprehensive strategies to prevent brain drain.

Figure 9. Brain Drain Rate of Higher Education Graduates by Department (2021–2023 Average, %)



Source: TÜİK.

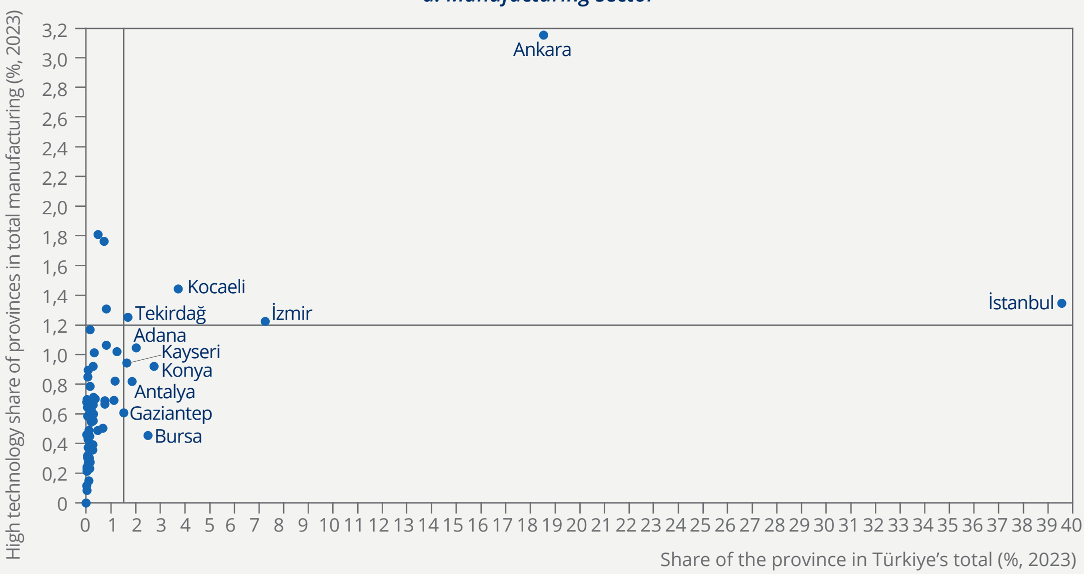
2.3.INTRA-COUNTRY ASYMMETRY IN TECHNOLOGICAL DEVELOPMENT



One of the most prominent structural hurdles faced by Türkiye is the lack of concentration in high technology manufacturing and service provision, made worse by the disparity between regions in these activities. The provincial distribution and intra-provincial density of workplaces engaged in high-tech manufacturing and service provision are presented in Figure 10. According to SSI data for 2023, only 1.1 percent[2] of the total number of manufacturing workplaces in Türkiye operate in high-tech sectors. There are five provinces that exceed the national ratio of high technology manufacturing sectors: İstanbul, Ankara, İzmir, Kocaeli, and Tekirdağ. These provinces account for 70.7% of the country's high-tech manufacturing activity and 76.6% of employees under the 4/1-a category (the article of the social security law governing the social insurance status of employees employed under an employment contract). A similar concentration is observed in the high-tech services sector; however, only three provinces İstanbul, Ankara and Kocaeli meet this criterion. These three provinces host 64.5% of all workplaces operating in high-tech service sectors and employ 77.9% of the country's 4/1-a category workforce in this field.

Figure 10. Number of Manufacturing and Services Sector Business in High-Tech and their Share in

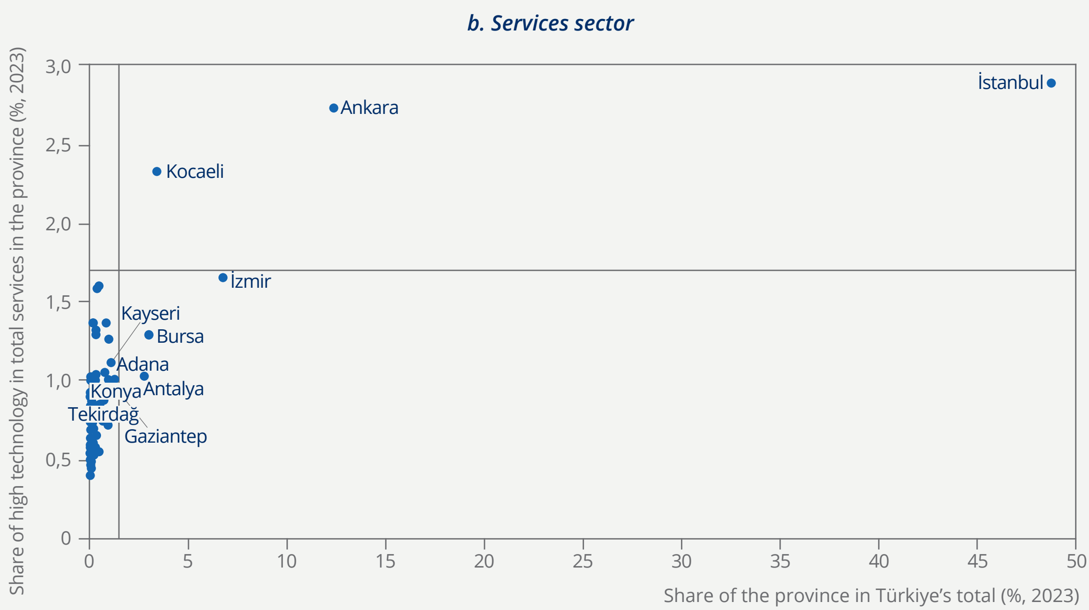
a. Manufacturing sector



2. As defined by Eurostat, the sectors coded 21 and 26 in the two-digit NACE classification are considered high-tech manufacturing, while the sectors coded 59, 60, 61, 62, 63 and 72 are considered high-tech services.

> According to TÜİK data, 29.7% of R&D expenditures in Türkiye are concentrated in Ankara and 28% in Istanbul, thereby deepening regional disparities.

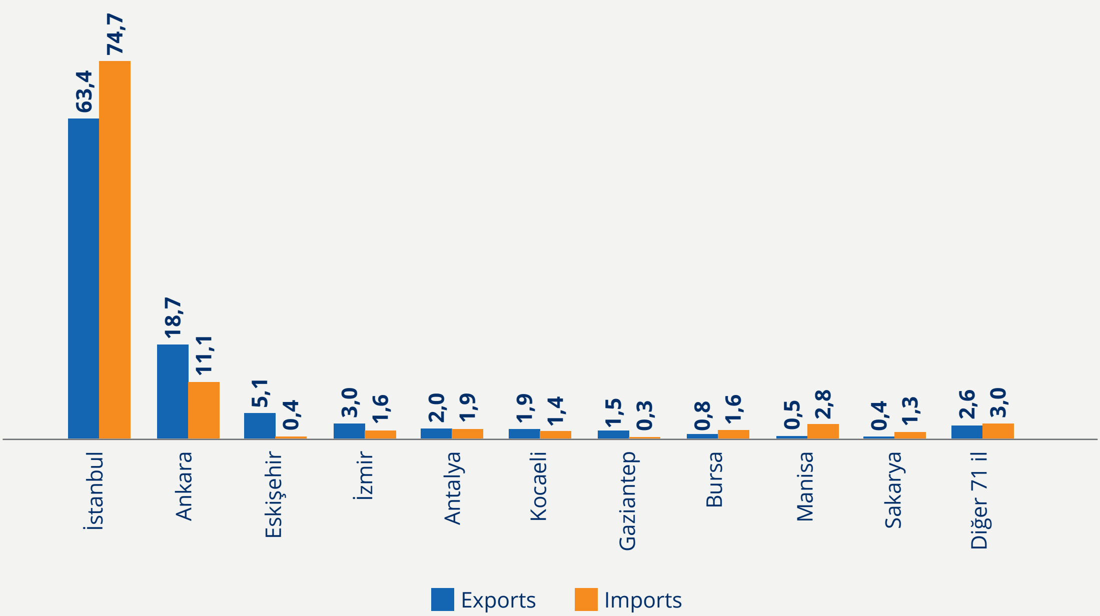
The Total of the Province (%, 2023)

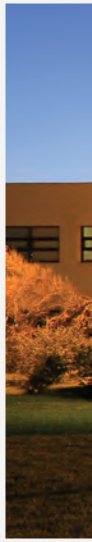


Source: SSI.

Foreign trade data supports these findings. İstanbul, Ankara and Eskişehir account for 87.1 percent of Türkiye's exports of high-tech goods,[3] while the share of these three provinces in the total imports of high-tech goods is 86.2 percent (Figure 11). An analysis of the provincial shares of high-tech products in total exports of goods reveals a difference between Eskişehir and Ankara and other provinces. According to TÜİK 2023 data, the share of high-tech products in total exports of goods was 3.77 percent in the country as a whole, compared to 30.23 percent for Eskişehir, 13.22 percent for Ankara, 7.31 percent for Antalya and 4.74 percent for İstanbul.

Figure 11. Provincial Distribution of Türkiye's Exports and Imports of Goods in High Technological Activity Areas (%, 2023)





Source: TÜİK.

In line with the differences in sectoral structure there are also significant differences between regions in terms of R&D expenditures and human resources. According to 2023 data released by TÜİK, the number of R&D personnel per 1,000 inhabitants nationwide reached 4.65. Moreover, the ratio of R&D expenditures to GDP rose from 1.32 percent in 2022 to 1.42 percent in 2023. Since the most recent regional GDP data is from 2022, the data for 2023 for the number of R&D personnel and 2022 for expenditure intensity are shown in Figure 12 for NUTS level 2 regions. It can be seen that Ankara and the Eastern Marmara Region (TR41 and TR42) performed above the national average in both

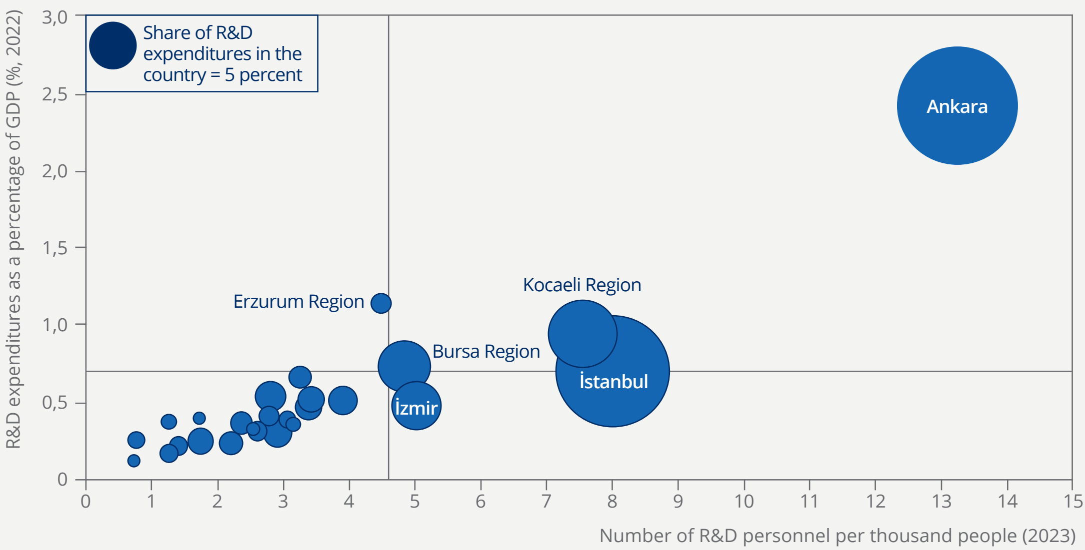
3. According to the United Nations definition of ISIC Rev. 3 sectors coded 353, 2423, 30, 32 and 33 in the classification are high-tech.

variables in the years in question. İstanbul and İzmir are regions with high R&D personnel density but bellow-average R&D expenditures compared to their economic size. The Erzurum Region (TRA1) has an R&D personnel density close to the average but draws attention due to the intensity of its R&D expenditures. Both the R&D personnel numbers and expenditure intensities of the other 20 regions are below the country average. It is worthy of note that 29.7 percent of the country's R&D expenditures were made in Ankara, 28.9 percent in İstanbul and 10.6 percent in Kocaeli, Sakarya, Düzce, Bolu and Yalova (TR42). In the NUTS level 2 classification, the ratio of R&D expenditures to GDP is above 1 percent in seven of the 26 regions, between 0.5 and 1 percent in 13 regions and below 0.5 in six regions.

ODTÜ Teknokent / Ankara

Composite indicators measuring regional socio-economic progress or competitiveness in Türkiye reveal significant developmental gaps between provinces and districts. Among these, the Socio-Economic Development Ranking Research (SEGE) serves as the main benchmark in related debates and forms the basis for regional incentive groupings. SEGE compares provinces' and districts' development levels using a broad set of variables, including demographic structure, education, health, employment, competitiveness, innovation and quality of life. A positive correlation can be expected between this level of development and readiness for technological transformation, since more advanced regions tend to offer diverse and abundant job opportunities, possess an educated workforce and have strong infrastructure and innovation capacity. In contrast, socio-economically underdeveloped regions are less prepared for technological transformation due to infrastructural deficiencies, low digital skills, limited innovation capacities and low likelihood of attracting the creative classes that facilitate adaptation.

Figure 12. R&D Intensity in NUTS Level 2 Regions

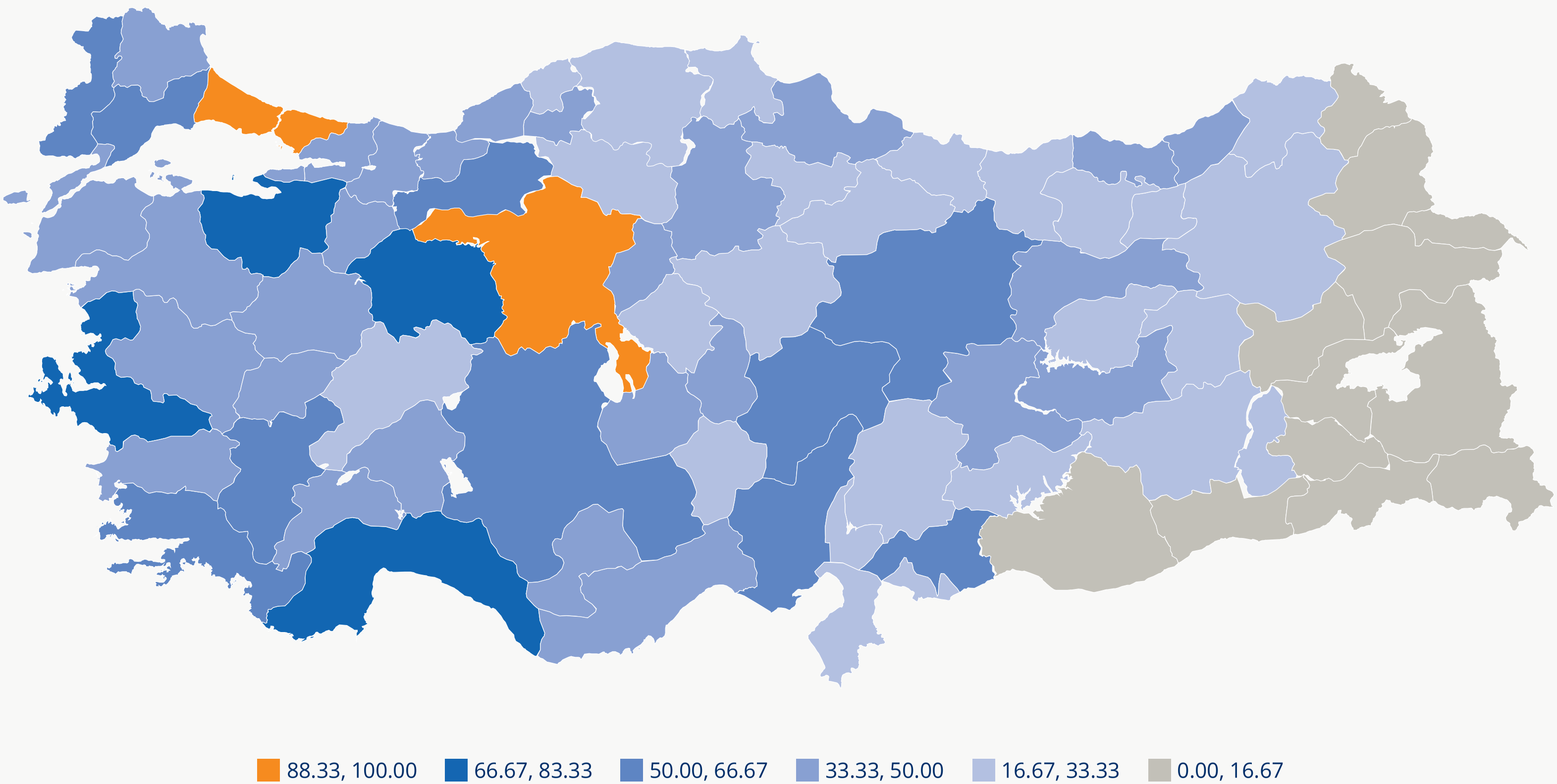


Source: TÜİK.

SEGE 2022 district results show that 67 out of 973 districts in Türkiye are at the first development level. Spread across 20 of Türkiye's 81 provinces, these districts constitute 2.76 percent of the country's total surface area, yet hosted 30.1 percent of the population in 2023. In other words, while the average population density in the first degree developed districts is 1195 people per km2, this figure is 78.6/km2 in other districts. While the total population in first-degree developed districts increased by 13.7 percent in the 2013–2022 period, the population of other districts increased by 10.2 percent. The fertility rate in the first-degree developed districts is lower than in other districts, suggesting that developed districts receive net migration, especially through the employment channel. As of 2023, although there are signs of migration from developed districts to other districts, especially due to the rising cost of living, these districts still retain their positions as centres of attraction for the labour force.

It was considered that the population-weighted sum of the district level SEGE 2022 scores could be used as the provincial score in an assessment of the socio-economic development status of the provinces. After applying this process, the scores were rescaled to a range of 0–100 using the min-max method and the provincial development levels in 2022 calculated based on these scores and using the equal intervals method are presented in Figure 13. As can be seen from the results, Ankara and İstanbul differ significantly from other provinces in the country in terms of their socio-economic development, followed by Bursa, Antalya, İzmir and Eskişehir. These six provinces are in the first two tiers and are home to 38.4 percent of the country's population and provided 54.3 percent of the gross domestic product, 49.1 percent of industrial value added and 62.3 percent of services value added in 2022.

Figure 13. Provincial Development Levels Calculated from District SEGE Scores (2022, Equal Intervals)



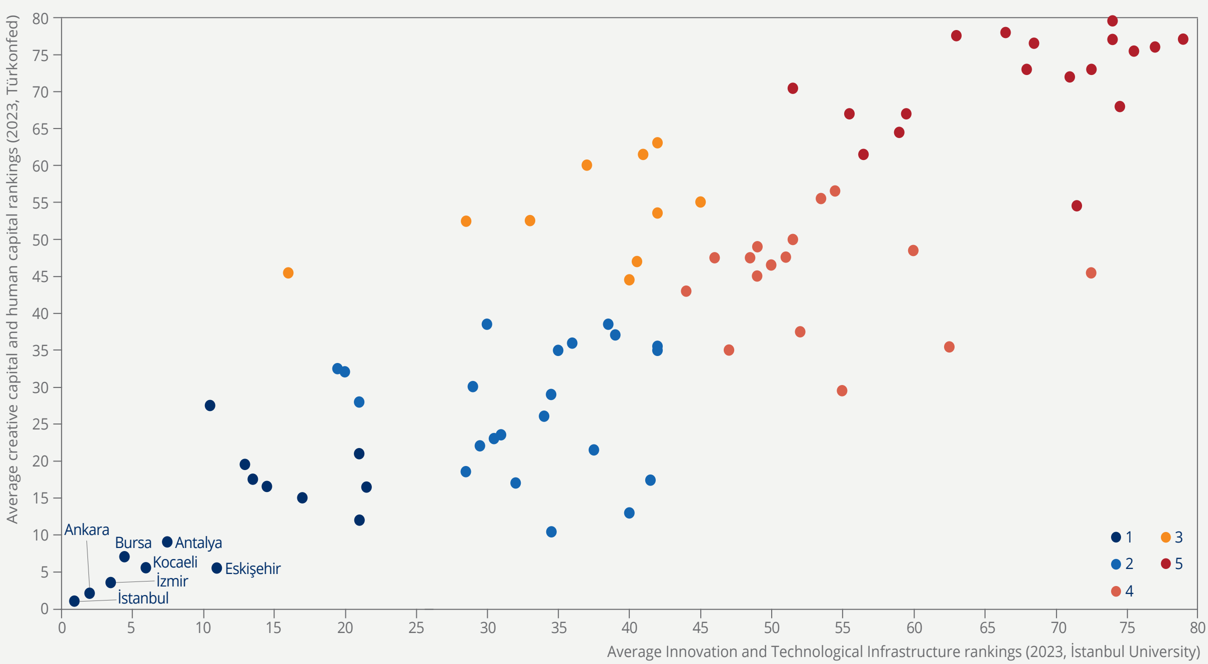
Source: Republic of Türkiye Ministry of Industry and Technology, TÜİK. .

There are two composite indexes measuring competitiveness at a provincial level, both published in 2023: the TÜRKONFED Competitiveness Index and the İstanbul Urban Policy Implementation and Research Centre's Inter-Provincial Competitiveness Index. These indexes differ in their methodologies, focus areas, and findings and they take different approaches to technological advancement. The TÜRKONFED Competitiveness Index does not directly include technological progress as a separate sub-index, but evaluates technological capacity through several indirect indicators. Notably, the creative capital index and the human capital index capture key factors fostering innovation and tech growth. The creative capital index evaluates a region's innovation potential, entrepreneurship and presence of creative industries. Creative capital is a cornerstone of an economy's ability to develop new technologies and embrace innovative business models. This index measures provinces' maturity in creative industries and their innovation capabilities. Meanwhile, the human capital index reflects the contribution of a skilled workforce to technological transformation. A highly educated and specialized labor force in high-tech is vital for sustaining technological advancement.

Bursa Model Factory / Bursa

İstanbul University's Inter-Provincial Competitiveness Index contains two sub-indexes that directly measure technological development, based on such indicators such as R&D activities, patent applications and the production of high-tech products in the provinces. This index evaluates how open provinces are to technological development and their innovation capacity, with factors such as R&D expenditures and university cooperations in particular indicating the extent to which provinces adopt technological innovations. The technological infrastructure index evaluates factors such as internet access, digital infrastructure and access to information technologies in the provinces. Provinces with strong technological infrastructures can adapt to digital transformation processes faster and have a competitive advantage in their use of technologies.

Figure 14. Cluster Analysis Based on Technological Development of Provinces (2023)



Source: İstanbul University Urban Policy Implementation and Research Centre, TÜRKONFED, EDAM.

Although the İstanbul University and TÜRKONFED competitiveness indexes differ in their approaches to technological advancement, conclusions can be drawn by evaluating their results together. While the İstanbul University report presents scores for provinces across each sub-index, the TÜRKONFED report only provides rankings. Therefore, synthesising the two indexes requires relying on rankings. A variable representing the human dimension of technological transformation was created by averaging the creative capital and human capital sub-index rankings from the TÜRKONFED index. Meanwhile, the İstanbul University index emphasizes the physical capital and output aspects of innovation by averaging the innovation and technological infrastructure sub-index rankings. Using these two variables and the k-means clustering method, provinces were grouped into five clusters. As shown in Figure 14, although 15 provinces fall into the first cluster, İstanbul, Ankara, İzmir, Bursa, Kocaeli, Antalya and Eskişehir—ranked within the top 11 on both variables—stand out positively from the other provinces in terms of their overall tech maturity defined by this method. Conversely, seven provinces rank among the lowest 11 on both variables: Kars, Siirt, Şırnak, Bitlis, Ağrı, Hakkari and Muş.

Figure 15 presents the average performance of the five clusters based on the two variables used in the analysis. To test the clustering's validity, the share of patent registrations by each cluster during 2019–2023 was examined. It was found that 87.1 percent of patents registered in Türkiye originated from the 15 provinces in the first cluster. Consistent with expectations, the share of patents decreases as the cluster's level of technological advancement declines.

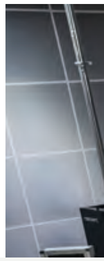
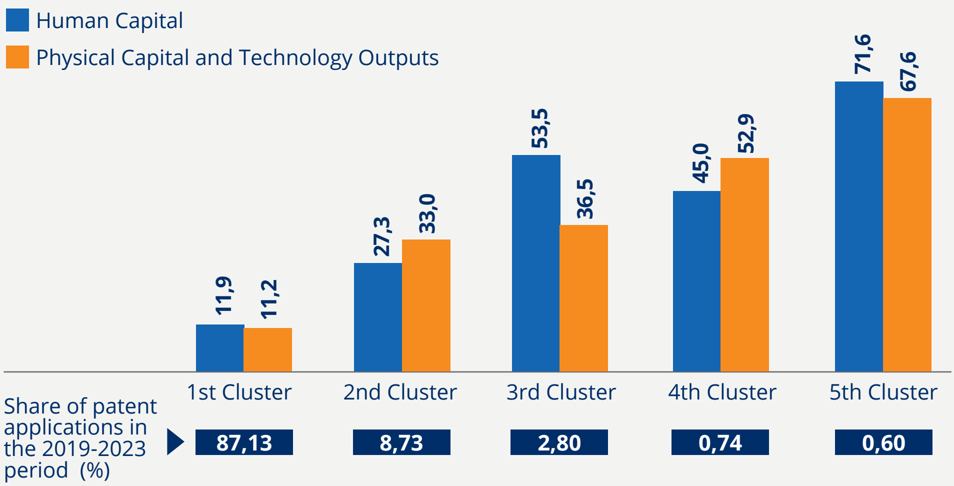


Figure 15. Technological Development Clusters Defined through a Cluster Analysis



Source: İstanbul University Urban Policy Implementation and Research Centre, Türkonfed, EDAM, Turkish Patent and Trademark Office.

This section presents an evaluation of the progress in Türkiye's technological transformation. According to the UNCTAD Productive Capacities Index and other international indicators, Türkiye has encountered difficulties in increasing its productive capacity and has lagged behind in directing the advantages of export diversification toward technology-intensive sectors. Furthermore, the regional concentrations of Türkiye's high-tech manufacturing and services sectors reveal the asymmetric structure within the country. More specifically, provinces such as İstanbul, Ankara, İzmir and Kocaeli offer significant advantages to technology-oriented enterprises and exports, while other provinces benefit less.

If Türkiye is to increase its global competitiveness, the technological transformation needs to benefit the entire country rather than being concentrated in certain provinces. Policies to eliminate the inequalities between provinces and regional support mechanisms should be prioritised. In this context, studies that present a detailed analysis of technological development on a provincial basis will be critical in accelerating Türkiye's technological transformation.

MEXT / İstanbul

> "Increasing Türkiye's global competitiveness requires the technological transformation to be spread across all provinces."


3

INDEX RESULTS AND MAIN FINDINGS

The data presented in the second part of this report reveals distinct differences between provinces in terms of their technology-oriented transformations. A deeper analysis of the technological development levels of Türkiye's provinces is of critical importance both in terms of understanding the current situation and determining the steps to be taken in the future. ASO's Technological Development Index of Provinces (ASO-İLTEK) study is designed to address this need. The main objective of the study is to measure the technological development levels of the 81 provinces in Türkiye based on objective criteria, and to use the acquired data to support the design of new industrial and regional policies.

> According to ASO-ILTEK data, Ankara, İstanbul, Eskişehir and Kocaeli are the provinces with the highest technological development in Türkiye, while these four provinces are clearly differentiated from other provinces.

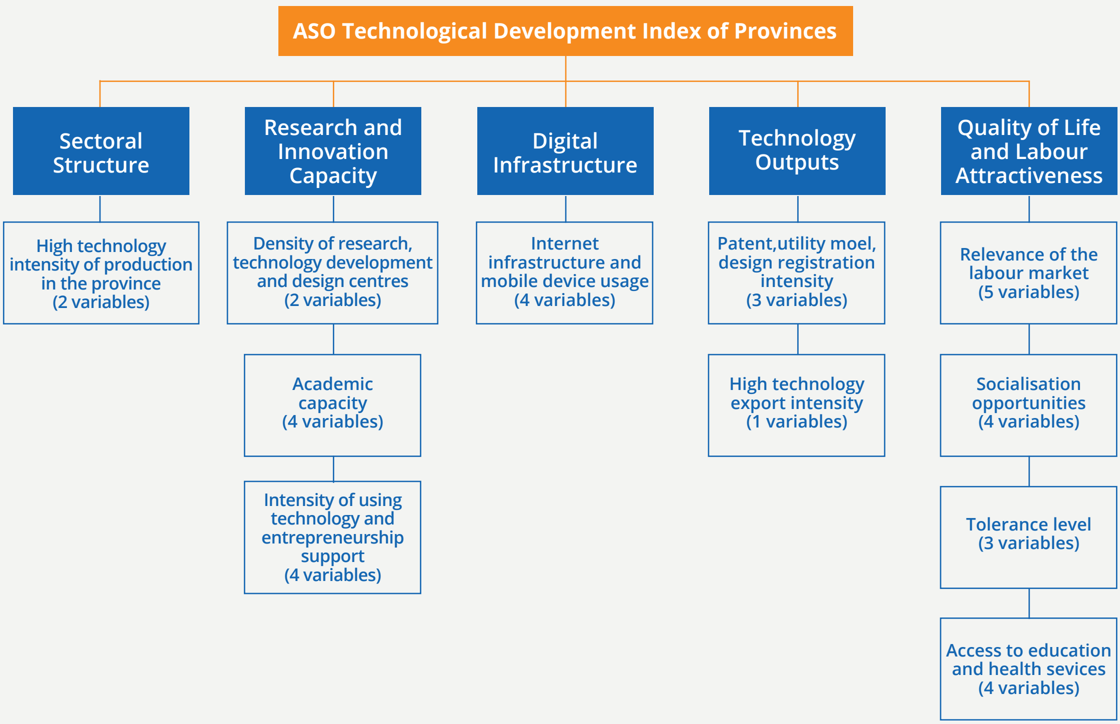
Technological development is a multidimensional concept that reflects the capacity of a country or region to produce, adapt and use technology, and is critical for economic growth, competitiveness, sustainable development and social welfare. As is the case with studies measuring other multidimensional concepts, such as competitiveness and socio-economic development, it is not possible to evaluate technological development based on a single indicator or area. For example, the United Nations Development Programme's (UNDP) Technology Achievement Index takes into account factors such as technology creation, technology diffusion and human skills when measuring technological development, while the World Bank measures such factors as the economic and institutional regime, education, innovation and information infrastructure of countries in its Knowledge Economy Index. WIPO's Global Innovation Index, which assesses the innovation performance of countries, is based on a broad set of indicators representing performance inputs and outputs.

> The sectoral structures of İstanbul and Ankara contribute more to high-tech production than all other provinces combined.

As is the case for other index studies, ASO-ILTEK has a multi-dimensional structure, as presented in Figure 16, comprising five sub-indexes representing the inputs, outputs, and facilitators of technology and innovation. The sectoral structure sub-index measures the high technology intensity of provincial production patterns, which is considered a facilitating factor in technological development. A province's capacity for research and innovation can be measured based on such variables as its institutionalised technology infrastructure, academic and institutional capacity, and the level of support provided for technology and entrepreneurship — all of which are considered inputs to technology and innovation processes.

On the other hand, the digital infrastructure sub-index — also positioned as an input to technological development — includes variables representing internet usage and speed. The quality of life and labour attractiveness sub-index is the most comprehensive due to the complexity of the concept it measures. This sub-index is included in the main index as a facilitator and is considered a measure of the ability of provinces to attract the necessary human resources for technological development. It is based on the measurement of such variables as the suitability of the labour market, opportunities for socialisation, tolerance levels (as a prominent factor in attracting the creative class), and access to education and health services — all of which determine the socio-economic development of the province and are among the main factors assessed by households when choosing a location.

Figure 16. Structure of ASO Technological Development Index of Provinces



After introducing the variables used in each sub-index of ASO-ILTEK, the rest of this chapter explains the methodology used in the construction of the index.

The first principal component obtained from the application of principal components analysis to the five sub-indexes explains 61.4 percent of the total variability in the sub-indexes. As can be seen in Table 1, the sub-indexes with the most significant weights in determining the technological development of provinces are research and innovation capacity, sectoral structure, and technology outputs.

Table 1. Weights of sub-indexes in the first principal component

Sub-index	First Principal Component Weight
Research and Innovation Capacity	0,5094
Sectoral Structure	0,4941
Technology Outputs	0,4826
Digital Infrastructure	0,4034
Quality of Life and Labour Attractiveness	0,3175

> ASO-ILTEK, which has a multidimensional structure, is a comprehensive study that reveals the inputs, outputs and facilitators of technology and innovation processes.

To classify the provinces into levels of technological development, three methods were applied, and the average of the results obtained from these methods was taken into account. First, five groups were defined with equal intervals of 0.2 points, with ASO-ILTEK scores greater than 0.8 considered first tier; scores of 0.6–0.8 considered second tier; 0.4–0.6 considered third tier; 0.2–0.4 considered fourth tier; and less than 0.2 considered fifth tier. Secondly, provinces were then classified into five groups through the application of the Jenks method, which determines the natural breaks in the main index scores of the provinces. Finally, the provinces were divided into five classes through the application of the k-means method. Based on the equal intervals method, in the other two methods, the names of the tiers were arranged so that the first tier included provinces with the highest main index scores, while the fifth tier included the provinces with the lowest index scores. The provinces were subjected to 8-level letter grading based on the averaging of the levels obtained using these three methods. The letter grades corresponding to each interval are shown in Table 2. For example, Kocaeli has a general index score of 0.7 and is ranked 2nd according to the equal intervals method. After applying the Jenks and k-means clustering method, the province was assigned to the first level and received a letter grade of AA, since the average of the levels in the three methods was 1.33. As another example, the general index score of Tekirdağ was 0.39, based on which, the province was assigned to the fourth tier according to the equal weights method. However, since it was identified as second level by the other two methods, the average level of Tekirdağ was calculated as 2.67 and its degree of technological development was determined as CB.

Table 2. ASO-ILTEK Ranking System

Average Tier*	Degree of Technological Development	Number of Provinces
(1, 1.5)	AA	4
(1.5, 2)	BA	0
(2, 2.5)	BB	4
(2.5, 3)	CB	4
(3, 3.5)	CC	25
(3.5, 4)	DC	8
(4, 4.5)	DD	20
(4.5, 5)	FF	16

**In each clustering method, the provinces with the highest index scores are identified as first tier and the provinces with the lowest index scores are identified as fifth tier, with lower levels numbers indicating a higher level of technological sophistication.*

> Many provinces in Türkiye can be considered as having potential based on their production of technologies and their adaptation capacities, although regional disparities exist.

The distribution of provinces according to their level of technological development is shown in Figure 17, and the general index scores of all provinces and their rankings in the general index and sub-indexes are presented in Table 3. Ankara, İstanbul, Eskişehir, and Kocaeli are the four provinces with the highest technological development scores, all of which have an AA ranking. There are no provinces with BA rankings, from which it can be understood that the technological development of these four provinces far exceeds that of all other provinces. İzmir, Bursa, Kayseri, and Sakarya — which hold positions 5 to 8 in the general index — are rated BB.

This distribution indicates the existence of two maintechnology belts in Türkiye: the İstanbul–Kocaeli belt, centred in İstanbul; and the Ankara–Eskişehir belt, centred in Ankara. An analysis of the provinces with BB and CB grades reveals a high level of technological development in the İstanbul–Kocaeli hinterland when compared to other provinces. It is also worthy of note that İzmir and Manisa have the potential to develop as a technology belt. As can be seen in Figure 18, which presents the average ASO-ILTEK technology generation and potential generation scores, the İzmir–Manisa belt closely resembles the expansion area of the İstanbul–Kocaeli belt. These two belts, which are geographically close to each other, can be considered natural overflow zones in the overall technological development of the country.

Figure 17. Classification of Provinces by Technological Development Tiers Based on ASO-İLTEK Scores (2024)

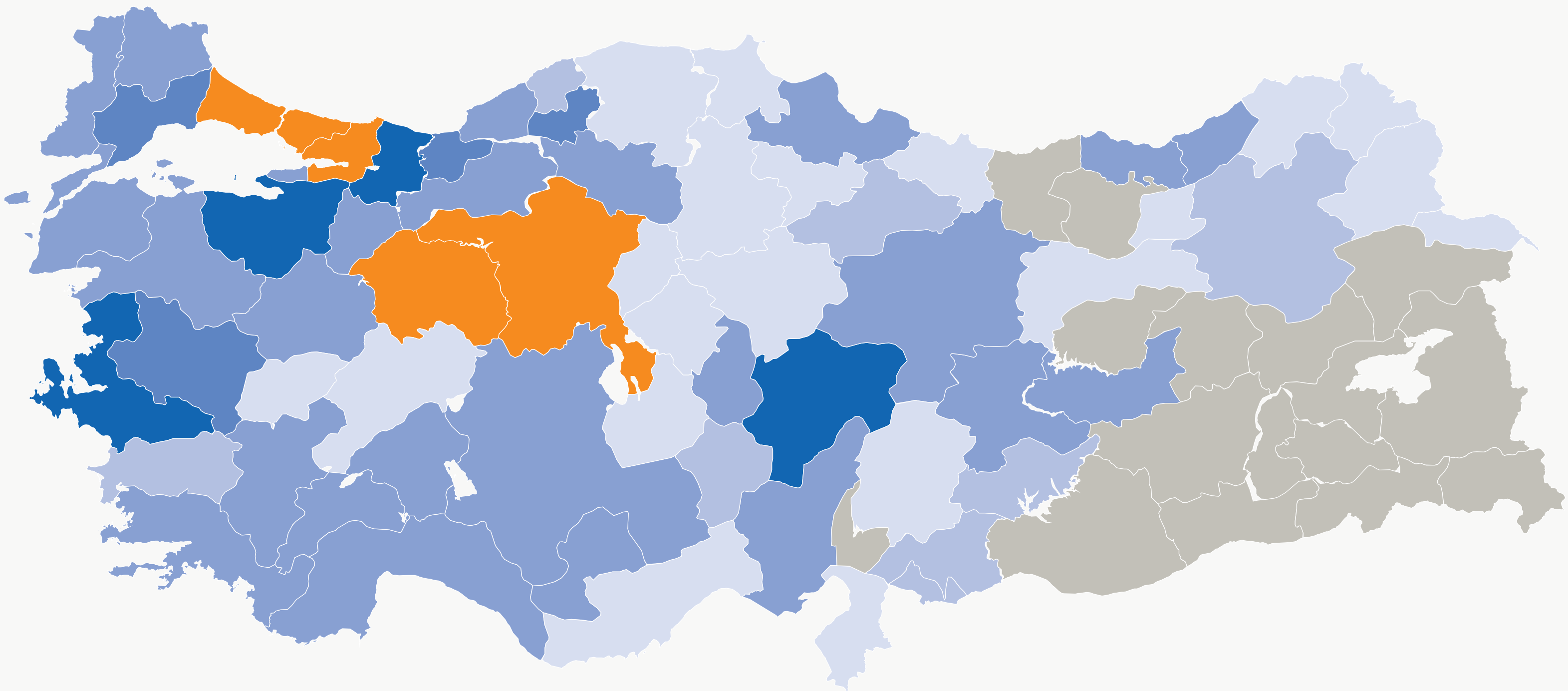


Table 3. ASO-ILTEK Index Results and Rankings (2024)

Province	Letter Grade	ASO Technological Development Index of Provinces (Score)	ASO Technological Development Index of Provinces (no.)	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour Attractive-ness (no.)
Ankara	AA	1,00	1	2	1	3	3	7
İstanbul	AA	0,94	2	1	4	1	1	24
Eskişehir	AA	0,80	3	4	2	12	4	8
Kocaeli	AA	0,70	4	3	3	9	7	3
İzmir	BB	0,53	5	5	7	6	9	14
Bursa	BB	0,51	6	10	9	13	2	44
Kayseri	BB	0,44	7	12	16	23	5	58
Sakarya	BB	0,41	8	19	10	27	6	26
Tekirdağ	CB	0,39	9	6	13	36	26	22
Karabük	CB	0,38	10	42	5	42	21	15
Düzce	CB	0,37	11	7	8	49	19	23
Manisa	CB	0,36	12	8	22	56	10	20
Antalya	CC	0,34	13	14	34	7	25	12
Denizli	CC	0,33	14	21	19	22	13	29
Trabzon	CC	0,33	15	24	11	16	32	31
Isparta	CC	0,32	16	26	12	30	23	17
Edirne	CC	0,31	17	17	29	17	65	2
Konya	CC	0,31	18	31	24	32	8	55
Bolu	CC	0,31	19	20	20	40	24	10
Çanakkale	CC	0,29	20	33	37	26	22	6
Adana	CC	0,28	21	15	32	5	44	63
Muğla	CC	0,28	22	36	52	15	62	1
Elazığ	CC	0,28	23	30	6	41	37	59
Kütahya	CC	0,28	24	52	14	37	35	16
Bilecik	CC	0,27	25	22	15	31	47	39
Yalova	CC	0,27	26	37	28	45	15	28
Rize	CC	0,27	27	38	25	33	31	21
Samsun	CC	0,27	28	23	30	24	29	37
Çankırı	CC	0,26	29	62	26	28	18	25
Malatya	CC	0,26	30	32	33	18	46	38
Zonguldak	CC	0,25	31	51	47	20	34	13

Province	Letter Grade	ASO Technological Development Index of Provinces (score)	ASO Technological Development Index of Provinces (no.)	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour Attractive-ness (no.)
Balıkesir	CC	0,25	32	43	48	25	39	11
Sivas	CC	0,24	33	16	18	47	55	45
Burdur	CC	0,23	34	76	23	54	20	18
Kırklareli	CC	0,23	35	9	38	66	73	5
Karaman	CC	0,23	36	70	31	48	14	32
Nevşehir	CC	0,23	37	56	41	53	17	27
Erzurum	DC	0,22	38	35	21	60	43	43
Gaziantep	DC	0,22	39	39	46	21	12	73
Bartın	DC	0,21	40	58	39	43	30	30
Aydın	DC	0,21	41	55	42	29	40	34
Kilis	DC	0,21	42	48	66	2	68	68
Adıyaman	DC	0,21	43	54	53	4	48	72
Tokat	DC	0,20	44	46	45	63	11	57
Niğde	DC	0,20	45	45	17	61	33	60
Mersin	DD	0,20	46	34	43	59	28	50
Kastamonu	DD	0,19	47	63	54	58	36	9
Amasya	DD	0,19	48	73	70	8	56	46
Ardahan	DD	0,19	49	81	74	10	80	4
Kırıkkale	DD	0,19	50	41	27	52	71	35
Uşak	DD	0,18	51	53	44	34	58	42
Aksaray	DD	0,18	52	71	73	11	49	56
Kars	DD	0,17	53	11	59	68	63	40
Artvin	DD	0,16	54	77	68	14	77	41
Kahramanmaraş	DD	0,16	55	40	49	39	45	71
Afyonkarahisar	DD	0,16	56	68	56	38	52	51
Çorum	DD	0,15	57	44	65	35	51	61
Hatay	DD	0,15	58	65	57	19	57	66
Bayburt	DD	0,15	59	57	69	57	41	52
Yozgat	DD	0,14	60	69	50	44	70	47
Erzincan	DD	0,14	61	47	58	62	76	33
Kırşehir	DD	0,14	62	78	62	51	42	54

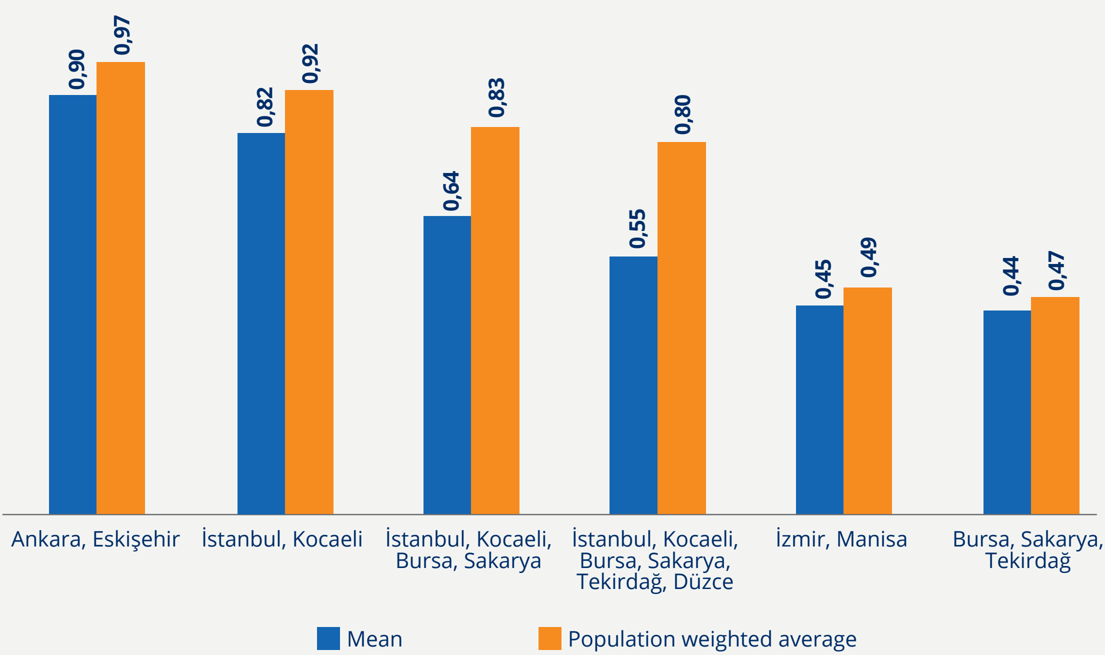
Table 3. ASO-ILTEK Index Results and Rankings (2024) - *(Continued)*

Province	Letter Grade	ASO Technological Development Index of Provinces (score)	ASO Technological Development Index of Provinces (no.)	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour Attractive-ness (no.)
Ordu	DD	0,13	63	67	78	46	54	49
Sinop	DD	0,12	64	74	76	67	50	19
Iğdır	DD	0,12	65	27	40	72	59	64
Tunceli	FF	0,11	66	80	67	74	27	36
Diyarbakır	FF	0,10	67	13	64	65	61	77
Ağrı	FF	0,10	68	25	79	55	72	69
Giresun	FF	0,10	69	79	60	64	69	48
Siirt	FF	0,09	70	64	63	76	16	70
Batman	FF	0,09	71	18	55	73	64	75
Osmaniye	FF	0,08	72	72	61	50	53	74
Bingöl	FF	0,08	73	75	72	70	66	53
Van	FF	0,08	74	28	36	71	67	79
Gümüşhane	FF	0,05	75	59	51	79	74	62
Bitlis	FF	0,04	76	50	71	78	79	65
Hakkari	FF	0,03	77	29	81	69	81	80
Şanlıurfa	FF	0,02	78	49	35	77	78	81
Mardin	FF	0,01	79	66	80	75	60	76
Muş	FF	0,01	80	61	75	80	75	67
Şırnak	FF	0,00	81	60	77	81	38	78

"Although İstanbul ranks first in Digital Infrastructure and Ankara leads in Research and Innovation Capacity in Türkiye, both provinces still lag significantly behind many global counterparts."

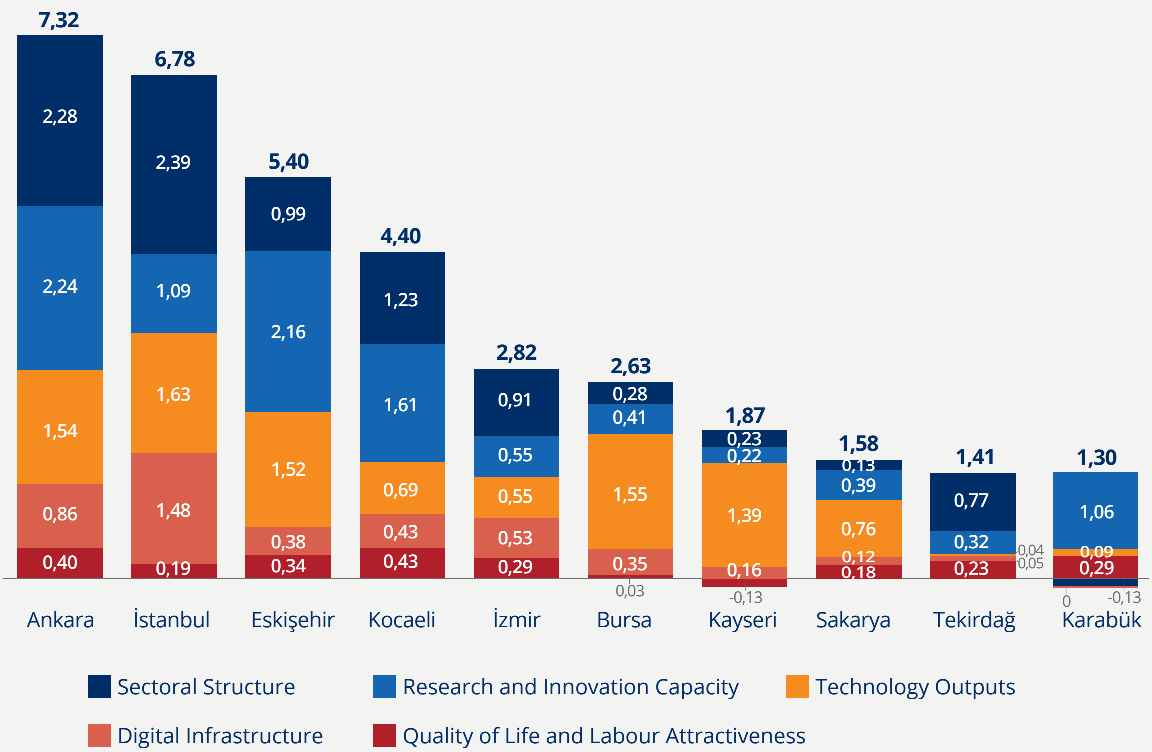
An analysis of the ASO-ILTEK sub-index rankings presented in Table 3 reveals differences in the factors that benefit or hinder each province. Notably, the quality of life and attractiveness for the labour force are the key factors that negatively affect Ankara and İstanbul, with İstanbul falling significantly behind Ankara in this regard. Another noteworthy difference between the two provinces is their research and innovation capacity. Although İstanbul ranks fourth in this sub-index, its score is only 57.1 percent of that of Ankara.

Figure 18. Technology Generations Defined According to ASO-ILTEK Results



Bilişim Vadisi / Kocaeli

Figure 19. Sub-index Analysis of the 10 Provinces with the Highest ASO-ILTEK Results



Note: When reporting the overall index, the first principal component score is rescaled between 0 and 1. Since the overall index is the first principal component of the five sub-index scores, it is obtained by multiplying and summing the standardised values of each sub-index score by their weights in the first principal component. For this reason, the first principal component score is used directly instead of the final index score scaled between 0 and 1 to indicate the sub-index contribution.

> According to the index results, the main factor placing Ankara ahead of İstanbul is Ankara's significant superiority in the Research and Innovation Capacity sub-index.

To facilitate a better understanding of provincial differences, the contribution of the sub-indexes to the overall index scores of the top 10 provinces in the ASO-ILTEK ranking is shown in Figure 19. As can be seen, the Research and Innovation Capacity and Quality of Life and Labour Attractiveness sub-indexes place Ankara 1.36 points ahead of İstanbul, while the Digital Infrastructure component pulls Ankara 0.62 points behind İstanbul. The most prominent reason for the distinction between these two provinces and the others is their Sectoral Structure. An analysis of the contribution of this sub-index to the overall index reveals a difference of 1.05 points between Ankara, which ranks second in this area, and Kocaeli, which ranks third.

When we examine the provinces rated BB and CB in the Sectoral Structure sub-index, it is noteworthy that no other provinces stand out apart from İzmir and Tekirdağ. İzmir, like the higher-ranking provinces, exhibits a relatively balanced profile across all five sub-indexes. In contrast, a large proportion of the overall index scores of Bursa, Kayseri, and Sakarya is driven by the Technology Outputs sub-index. Meanwhile, 54.7 percent of Tekirdağ's overall index score originates from its Sectoral Structure, while 81.3 percent of Karabük's overall index score is attributed to its Research and Innovation Capacity.

METU Micro-Electro-Mechanical Systems Research and Application Centre (MEMS) / Ankara

3.1. SECTORAL STRUCTURE SUB-INDEX RESULTS

As with the general index, the provinces were grouped into five categories for each sub-index using the equal intervals, natural breaks, and k-means methods. The average of the three classifications was then used to determine the letter grade for each province in the respective sub-index. The distribution of letter grades according to the Sectoral Structure sub-index is presented in Figure 20. İstanbul and Ankara received AA ratings in terms of their sectoral structure, followed by Kocaeli, Eskişehir, İzmir, and Tekirdağ, each of which received a BB rating. The remaining 75 provinces were rated CC or lower in this sub-index.

Technopark İzmir / İzmir

İstanbul and Ankara, which hold the top two rankings in the Sectoral Structure sub-index, stand out from all other provinces due to their exceptionally high production technology intensities. The average Sectoral Structure score for these two provinces is 0.98, compared to 0.51 for the four provinces rated BB, and just 0.13 for the remaining 65 provinces. The rankings of the 60 provinces that received DD or FF grades in this sub-index clearly illustrate the regional disparities in technology-oriented investments. These provinces have an average Sectoral Structure score of only 0.10.

Figure 20. ASO-ILTEK Sectoral Structure Sub-index Average Grades

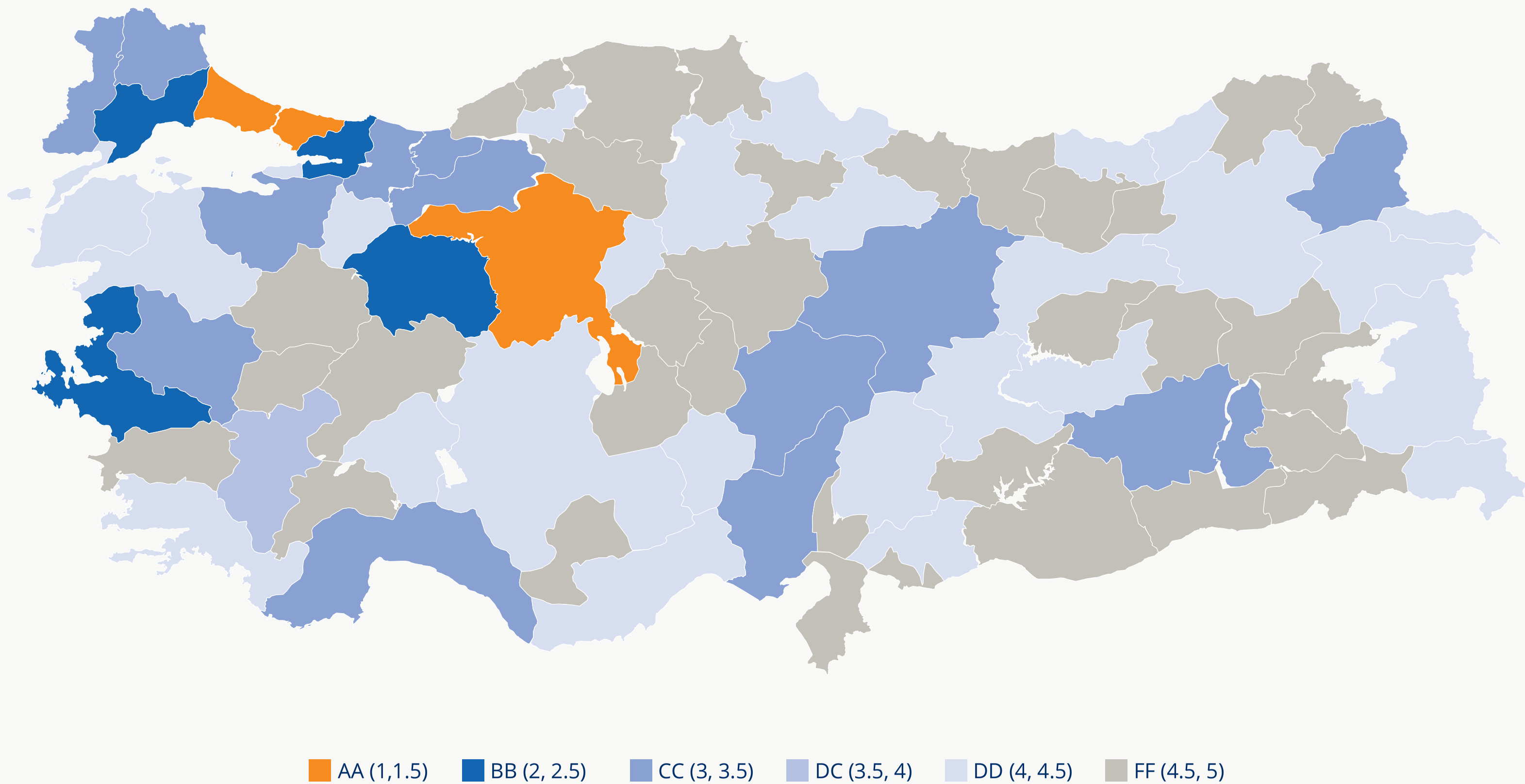


Figure 21. Relationship of Sectoral Structure Sub-index with Other Sub-indexes and SEGE

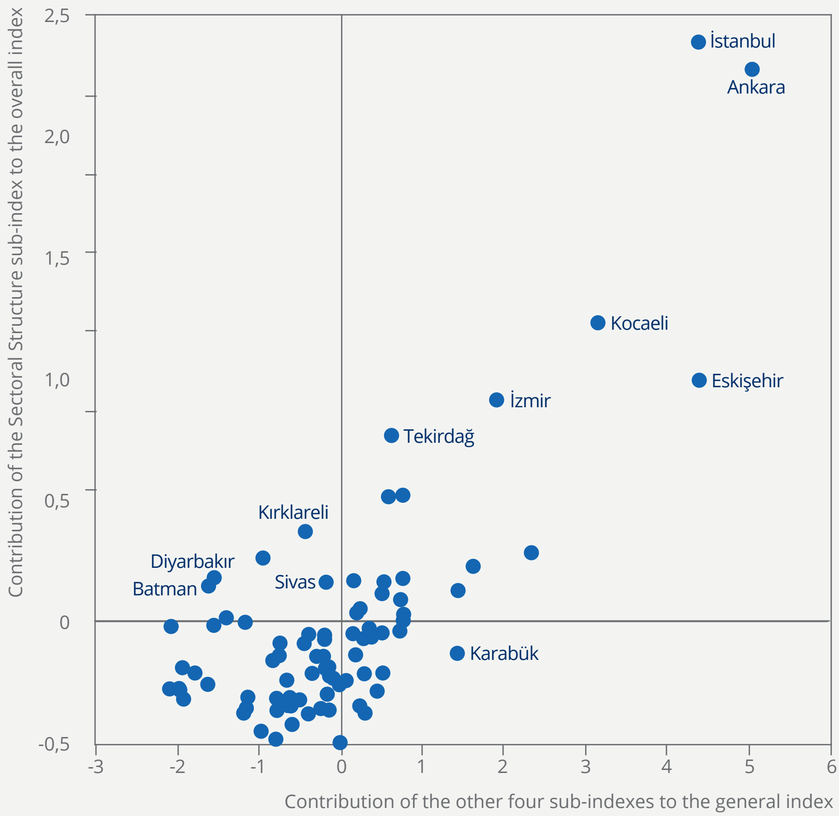
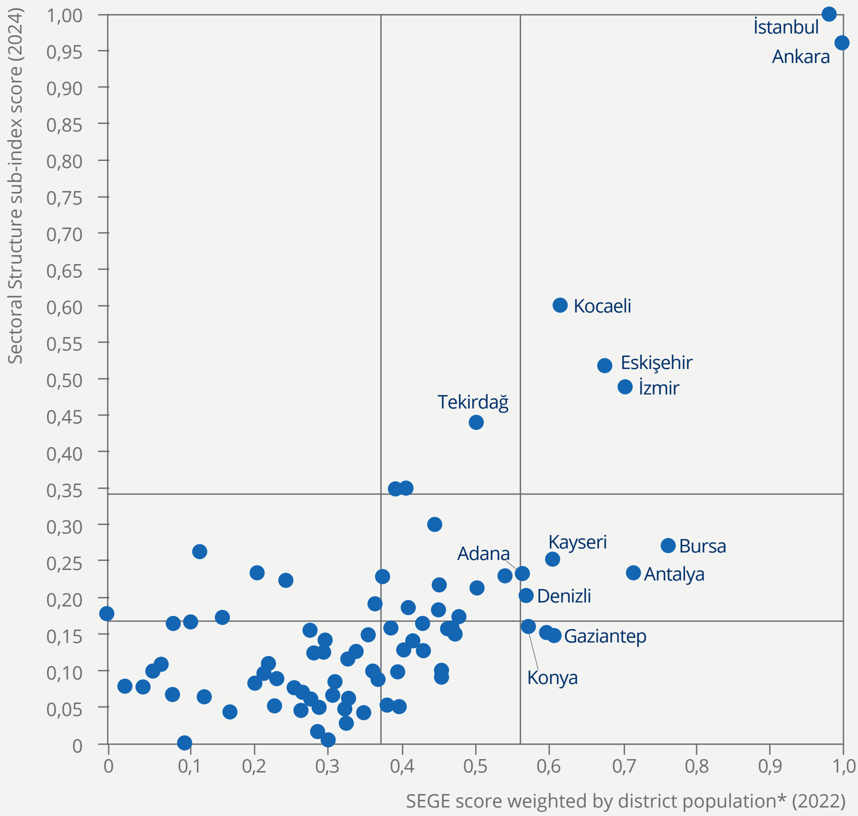


Figure 21 presents two comparisons of sectoral infrastructure index performances of the provinces. The first shows the contributions of the sectoral structure and the other four sub-indexes to the overall index score, which is not rescaled to range between 0 and 1. Provinces in which both sectoral structure and other sub-indexes contribute positively to the general index are located in the upper right quadrant. Approximately one-third of the overall index scores of İstanbul, Ankara, and İzmir can be attributed to their sectoral structures, while this ratio is 18.4 percent in Eskişehir and 54.8 percent in Tekirdağ. It is noteworthy, however, that the sectoral structure index scores of some provinces differ from expectations when controlling for the two indicators used in the comparison. Karabük's performance is unique due to the positive contribution from the sum of the other four areas, while its sectoral structure negatively impacts its general index. Provinces such as Kırklareli and Diyarbakır show a positive contribution from the sectoral structure, while the other four areas contribute negatively to their general index.



*Source: Republic of Türkiye Ministry of Industry and Technology, TEPAV calculations. *Provincial scores – calculated as the weighted averages of SEGE district 2022 index scores with district populations – are rescaled to between 0 and 1 using the min-max method. In the plotted sub-index score-SEGE scores, the axes are cut at the mean scores and are 1 standard deviation above the mean.*

In the second graph, presented in Figure 21, the provinces are grouped into three categories based on their SEGE and sectoral structure index scores. Provinces with below-average scores are classified as low, those with scores between the average and one standard deviation above the average are classified as medium, and the remaining provinces are classified as high. This classification reveals that high socio-economic development provinces such as Gaziantep and Konya fall into the low category in terms of sectoral structure, while other high socio-economic development provinces such as Kayseri, Bursa, Antalya, and Denizli show average sectoral structure performances. Among the 81 provinces, 36 belong to the low socio-economic development-low sectoral structure group, while 15 fall into the medium socio-economic development-low sectoral structure group.

3.2. RESEARCH AND INNOVATION CAPACITY SUB-INDEX RESULTS

The letter-grade distribution of the provinces according to the Research and Innovation Capacity sub-index is presented in Figure 22. Ankara and Eskişehir are rated AA in this category, followed by Kocaeli with a BA rating, and İstanbul and Karabük with BB ratings. Elazığ has a CB letter grade, while 11 of the remaining 75 provinces are rated CC, three are rated DC, 21 are rated DD, and 20 are rated FF.

Ankara and Eskişehir, both rated AA, have similar sub-index scores, averaging 0.99. Kocaeli's sub-index score corresponds to 77 percent of Ankara's, while İstanbul's is only 57 percent. This disparity can be attributed to the ratio of index-related variables to the number of enterprises. For instance, although 32.1 percent of all R&D centres are located in İstanbul and 11.4 percent in Ankara, the number of R&D centres per 1,000 enterprises is 12.8 in Kocaeli, 4.3 in Eskişehir and Ankara, and 3.6 in İstanbul. Similarly, Ankara and İstanbul lag behind in the number of technology development zones and design centres when adjusted for the number of enterprises.

Karabük and Elazığ stand out with high research and innovation capacities, largely due to the concentration of students and academicians in technology-oriented university departments. Karabük differs from other provinces with a high number of technology development and design centres relative to its enterprise base, while Elazığ is distinguished by its high volume of academic publications, university projects, and the number of companies benefiting from industrial and entrepreneurship support. Despite these strengths, the sub-index scores of Elazığ and Karabük correspond to 40 percent and 56 percent of Ankara's score, respectively .

Eskişehir OIZ / Eskişehir

Figure 22. ASO-ILTEK Research and Innovation Capacity Sub-index Average Grades

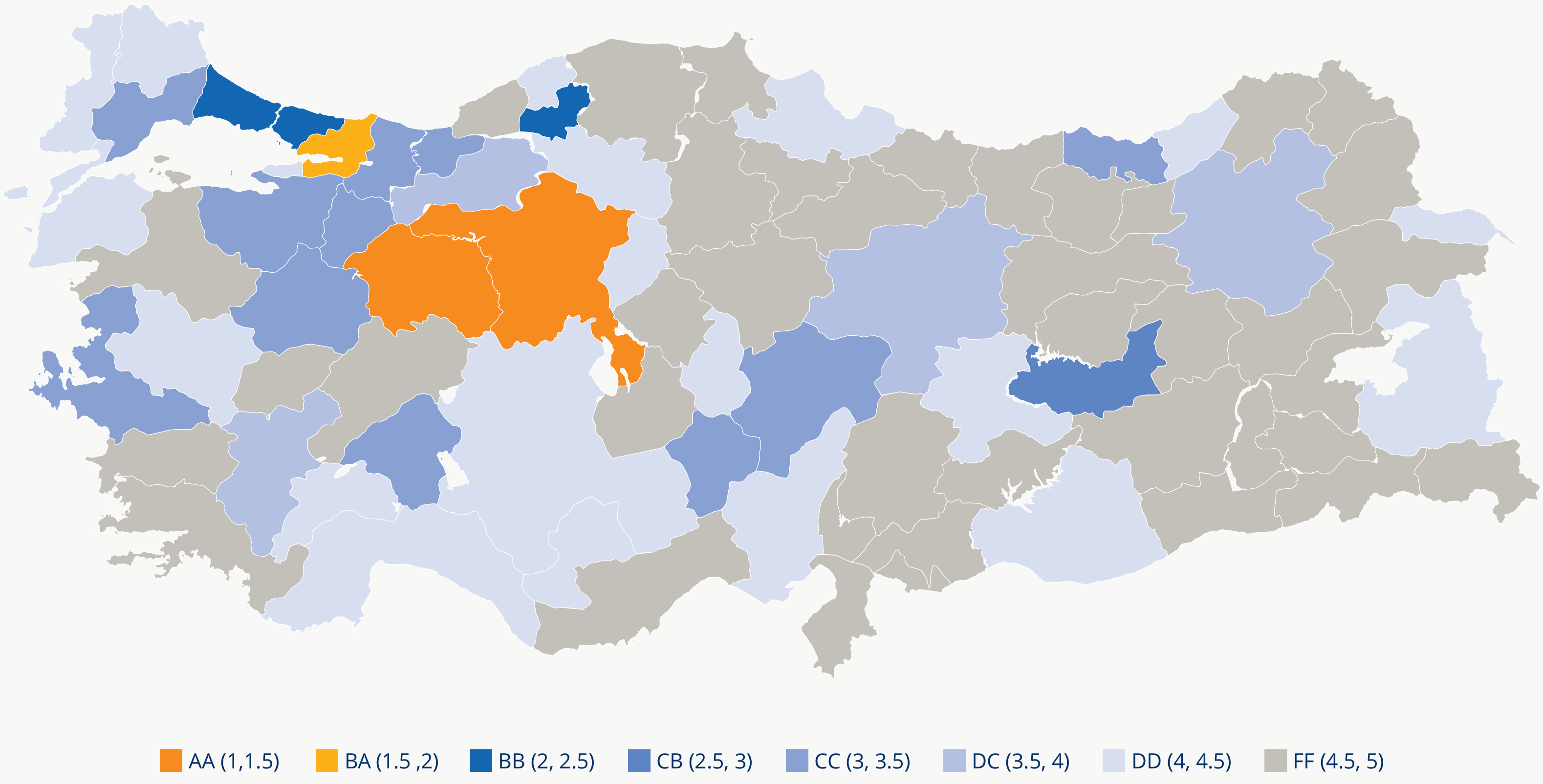
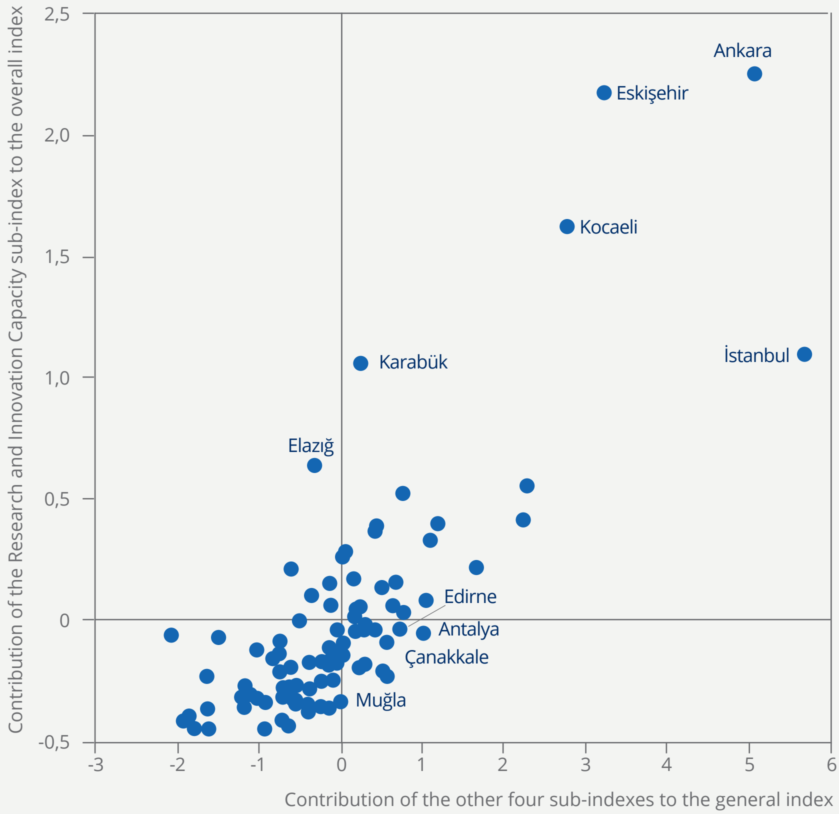
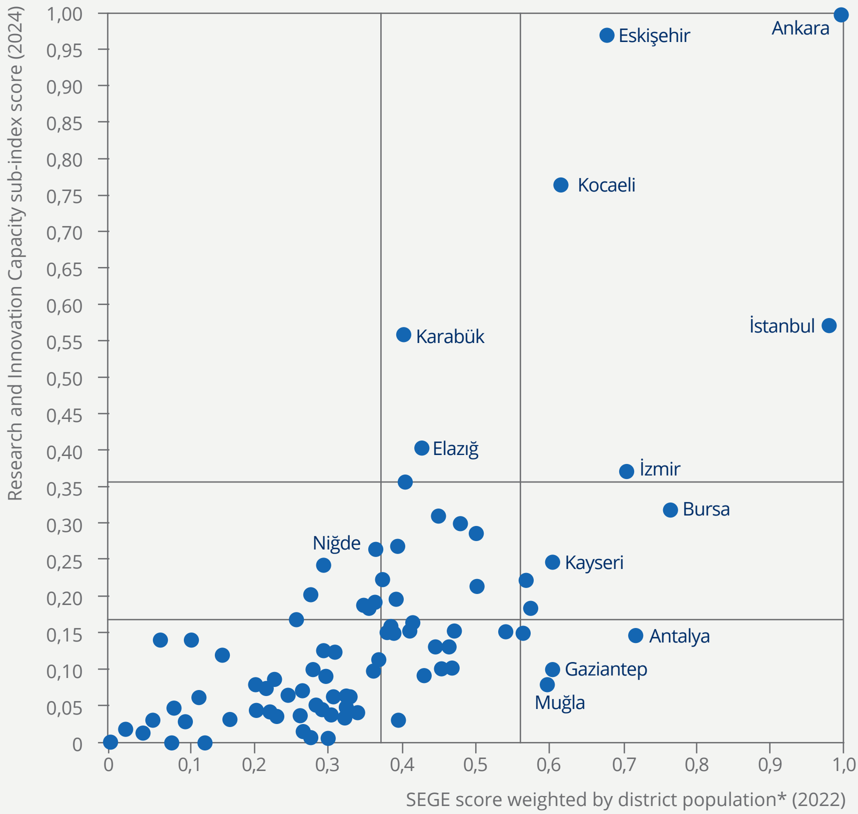


Figure 23. Correlation of Research and Innovation Capacity Sub-index with other sub-indexes and SEGE



*Source: Republic of Türkiye Ministry of Industry and Technology, TEPAV calculations. *Provincial scores – calculated as the weighted averages of SEGE district 2022 index scores with district populations – are rescaled to between 0 and 1 using the min-max method. In the plotted sub-index score-SEGE scores, the axes are cut at the mean scores and are 1 standard deviation above the mean.*

Figure 23 presents a comparison between the Research and Innovation Capacity sub-index, other sub-indexes, and the SEGE classification in terms of their contributions to the overall index score. Research and Innovation Capacity accounts for 40% of Eskişehir's overall index score, 36.6% in Kocaeli, 30.7% in Ankara, and only 16% in İstanbul. It is observed that the other sub-indexes contribute almost nothing to the overall index scores of Karabük and Elazığ, which stand out primarily due to their strong performance in the Research and Innovation Capacity sub-index. Conversely, in provinces such as Antalya, Muğla, and Çanakkale, the overall contribution of the other sub-indexes is positive, while the Research and Innovation Capacity sub-index actually lowers their overall index performance. Among all sub-indexes, Research and Innovation Capacity is the most strongly correlated with the contribution of other sub-indexes to the overall index.



When socio-economic development level and research and innovation capacity performance are considered together, 36 provinces are clustered in the lower-left quadrant, representing the low socio-economic development-low research and innovation capacity category. It is worth noting that, while Bursa and Kayseri, as provinces with high socio-economic development, fall into the medium category in terms of research and innovation capacity, Gaziantep, Antalya, and Muğla are categorized as low.

3.3. DIGITAL INFRASTRUCTURE SUB-INDEX RESULTS

Figure 24 shows the distribution of provinces by letter grades based on their digital infrastructure index scores. İstanbul stands out as the leader in digital infrastructure development, while three other provinces—Kilis, Ankara, and Adıyaman—also received AA rankings. The unexpected high scores of Kilis and Adıyaman may be linked to their high Syrian population density. For example, Kilis ranks second in the number of broadband subscribers in proportion to population variable and the number of mobile devices with 3 or 4.5G connections, and third in the number of mobile broadband subscribers variable. However, when the Syrian population is included in the provincial population numbers, Kilis ranks 18th in the number of broadband subscribers and seventh in the number of mobile broadband subscribers and ownership of mobile phones with 3 or 4.5G connections. Indeed, as shown in Annex 3, when the Syrian population is included in the analysis, Ankara and Adıyaman are downgraded to BA and Kilis is downgraded to DD in this sub-index. According to the original index, 59 out of 81 provinces have a digital infrastructure score of CC or below, however, this number decreases to 49 when the Syrian population is included in the analysis. Figure 24 reveals that most of the border provinces perform strongly in the digital infrastructure component, which can be attributed to the bias of the "border effect" noted in academic literature that has been linked to smuggling, as well as the intensity of foreign enterprises and border trade.

> "In the Technology Outputs sub-index, there is a significant score difference between the first group, which includes İstanbul, Bursa, Ankara, Eskişehir and Kayseri, and the following group, which includes Sakarya, Kocaeli, Konya, İzmir and Manisa."

Among the five variables included in the digital infrastructure index, the only variable in which İstanbul is not ranked first is the share of those with fibre connections in the number of fixed broadband subscribers. The top three provinces in this variable are Kayseri, Ankara and Tekirdağ. Speedtest's internet speed data for the last quarter of 2023 shows that internet speed in İstanbul is higher than other major provinces, but well below the average of other countries. The median fixed broadband download speed is 47.81 Mbps in İstanbul, 42.76 Mbps in Ankara, 41.21 Mbps in İzmir, 35.02 Mbps in Adana and 30.48 Mbps in Bursa. On Speedtest's list of 161 countries around the world ranked by internet download speed for August 2024, Ankara ranked 82nd with 57.16 Mbps and İstanbul ranked 85th with 57.07 Mbps. Considering that Sofia, Bulgaria ranks 11th with a speed of 212.47 Mbps and Sao Paulo, Brazil ranks 15th with a speed of 192.07 Mbps in the same list, it can be concluded that our provinces have an obvious internet speed problem.

Figure 24. ASO-ILTEK Digital Infrastructure Sub-index Average Levels

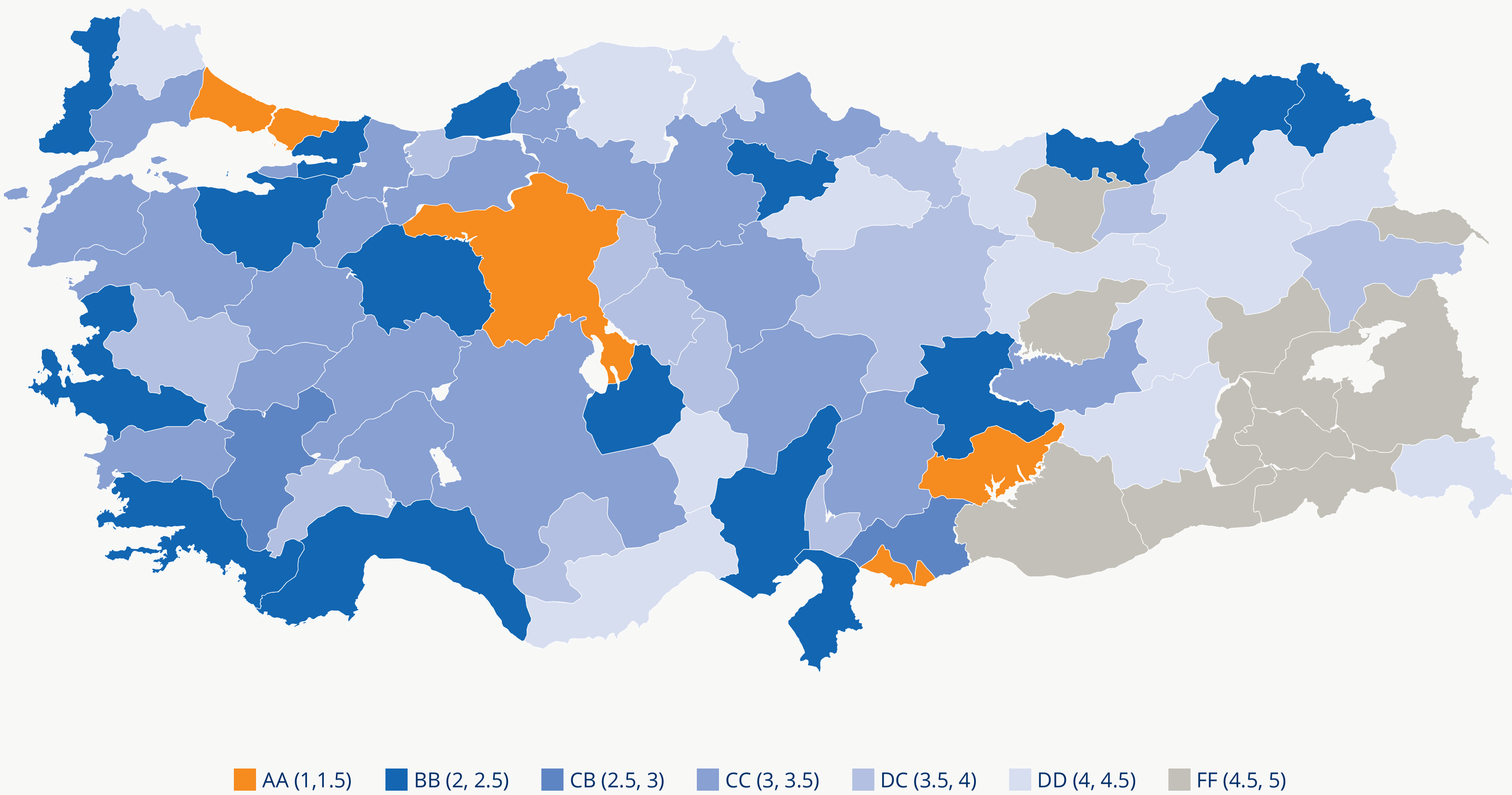
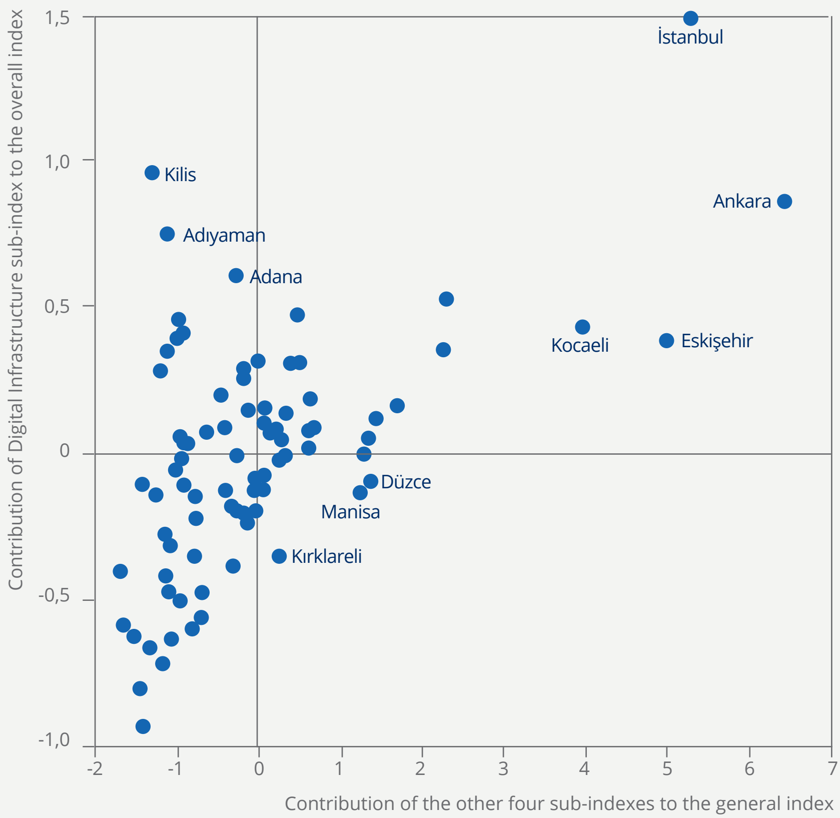


Figure 25. Relationship of Digital Infrastructure Sub-index with Other Sub-indexes and SEGE



*Source: Republic of Türkiye Ministry of Industry and Technology, TEPAV calculations. *Provincial scores – calculated as the weighted averages of SEGE district 2022 index scores with district populations – are rescaled to between 0 and 1 using the min-max method. In the plotted sub-index score-SEGE scores, the axes are cut at the mean scores and are 1 standard deviation above the mean.*

Figure 25 presents a comparison of the digital infrastructure sub-index with the other sub-indexes and SEGE in terms of their contributions to the overall index. The provinces in which the digital infrastructure sub-index contributes the most to the overall index are İstanbul, Ankara, Kilis, Adıyaman and Adana. However, in Kilis, Adıyaman and Adana, digital infrastructure is the main contributor to the overall index, while the four sub-indexes pull down their overall performance. A comparison of the overall index scores of İstanbul and Ankara reveals that 21.9 percent and 11.7 percent, respectively, can be attributed to their digital infrastructures. The contribution of the digital infrastructure sub-index to the overall index in Ankara is 57.8 percent that of İstanbul. On the other hand, in provinces such as Düzce, Manisa and Kırklareli, the total contribution of the other four sub-indexes to the overall index is positive, while the contribution of the digital infrastructure sub-index is negative.

In comparison of the digital infrastructure sub-index scores with SEGE performance, Kırklareli is among the provinces with a medium socio-economic development level but low digital infrastructure performance. In terms of socio-economic development levels, Ardahan, Adıyaman and Kilis stand out as the provinces with the highest digital infrastructure performances, while Mersin, Bursa, Konya and Ankara stand out as provinces with the lowest.

3.4. TECHNOLOGY OUTCOMES SUB-INDEX RESULTS

The letter grade distribution of provinces assigned based on the technology outputs sub-index is presented in Figure 26. İstanbul, Bursa, Ankara, Eskişehir and Kayseri are rated AA in terms of technology outputs, followed by Sakarya, Kocaeli, Konya, İzmir and Manisa with a BB ranking. The fact that there is no province with a BA grade can be attributed to the broad gap between the AA group and the other provinces in this regard. The average technology output sub-index score of the five provinces in the AA group is 0.95, while the average score of the five provinces in the BB group is 0.53. The average sub-index scores of the other 71 provinces is 0.16, and among these, 46 received DD or FF grades in terms of technology outputs.

Denizli, Konya and Gaziantep are ranked 21st, 31st and 39th, respectively, in the sectoral structure index, although they notably ranked 13th, 8th and 12th in the technology outputs sub-index. A similar situation applies to Bursa and Kayseri, which rank 10th and 12th in terms of sectoral structure, but 2nd and 5th in terms of technological output. The structures of these provinces differ from those of other provinces, with clusters of traditional sectors developing alongside intensive innovative activities. Tekirdağ is particularly noteworthy, ranking sixth in the sectoral structure index but 26th in the technology outputs sub-index, despite its technology-intensive sectoral structure, which can be attributed to a lack of efficiency.

Kocaeli University / Kocaeli

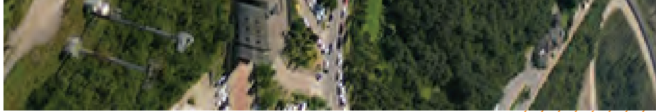


Figure 26. ASO-ILTEK Technology Outputs Sub-index Average Levels

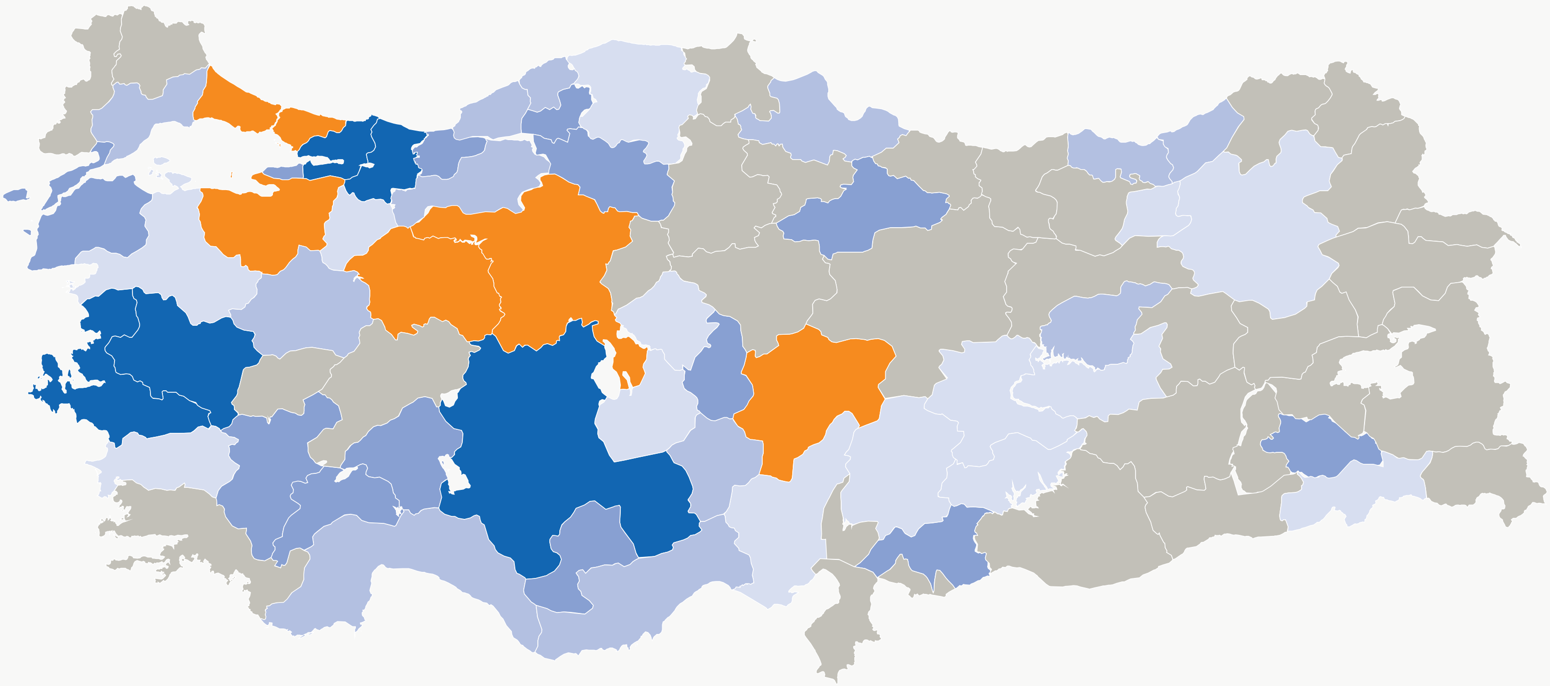
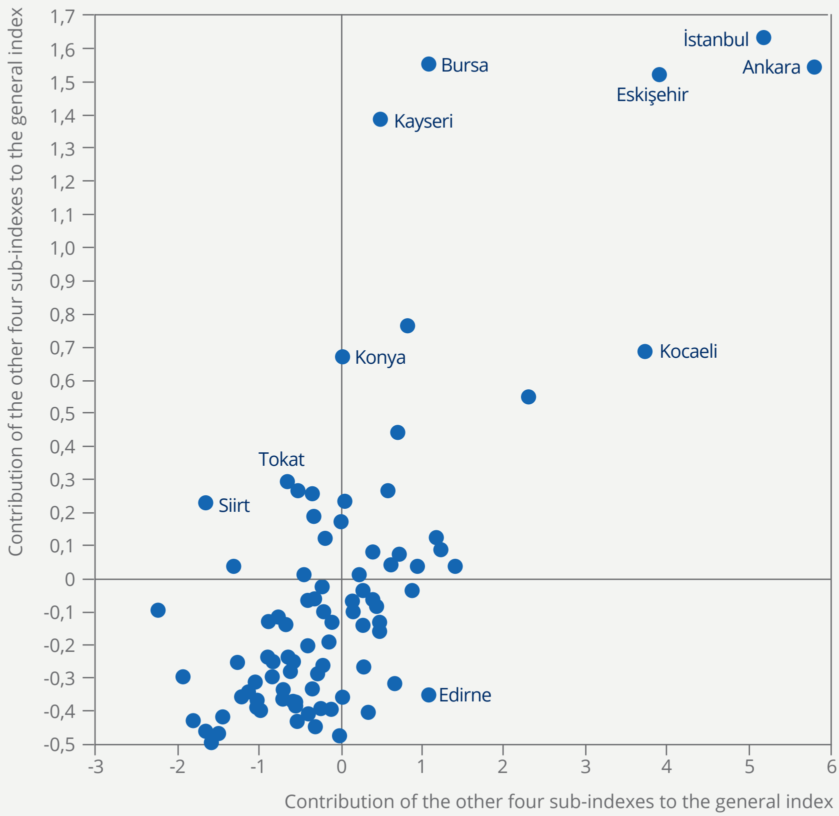
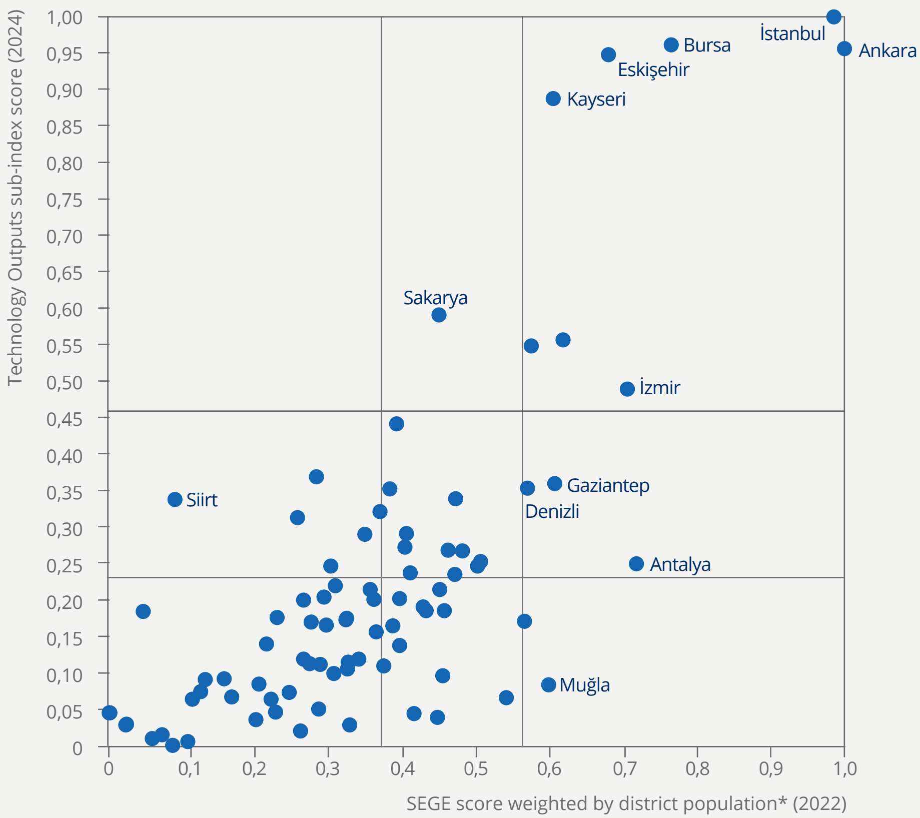


Figure 27. Relationship of Technology Outputs Sub-index with Other Sub-indexes and SEGE



*Source: Republic of Türkiye Ministry of Industry and Technology, TEPAV calculations. *Provincial scores – calculated as the weighted averages of SEGE district 2022 index scores with district populations – are rescaled to between 0 and 1 using the min-max method. In the plotted sub-index score-SEGE scores, the axes are cut at the mean scores and are 1 standard deviation above the mean.*

Figure 27 presents a comparison of the technology outputs sub-index with the other sub-indexes and SEGE in terms of their contributions to the overall index. The technology outputs sub-index accounts for 74.6% of the overall index score in Kayseri and 59% in Bursa, while the contributions from the other four sub-indexes to their overall scores are relatively small. The average contribution of technology outputs to the overall index in the 10 provinces with the highest technology output sub-index scores is 42.7%. In contrast, Kocaeli and İzmir, which are also among the top 10 provinces, have much lower contributions—15.7% and 19.4%, respectively. Edirne is one of the provinces where technology outputs contribute negatively to the overall index, while the other four sub-indexes contribute positively. On the other hand, in provinces like Gaziantep, Karaman, Tokat, and Siirt, technology outputs contribute positively, while the other sub-indexes have a negative impact.



In a comparison of the technology output sub-index scores with the SEGE performance, Sakarya stands out as a province with a medium socio-economic development level but high technology output performance. Although Muğla has a high level of socio-economic development, it is in the low category in the field of technology outputs due to the lack of development of its technology ecosystem. The socio-economic development level and the level of technology outputs are the same in 56 provinces. Only 6 of the other 25 provinces are in a technology output category higher than their socio-economic development category.

3.5. QUALITY OF LIFE AND LABOUR ATTRACTIVENESS SUB-INDEX RESULTS

The letter grade distribution under the Quality of Life and Labour Attractiveness sub-index is presented in Figure 28. Muğla, Edirne, Kocaeli, Ardahan, Kırklareli, Çanakkale and Ankara are all rated AA, with an average score of 0.89 in this area. Eskişehir, Kastamonu, Bolu, Balıkesir and Antalya, which hold BB grades, have an average score of 0.79. At the lower end, 11 provinces have a DD ranking and nine are rated FF. Most of these 20 provinces, with an average score of 0.23, are located in south-east Türkiye.

> Despite its high employment capacity and rapid growth rate, İstanbul lags behind Ankara in the Quality of Life and Labour Attractiveness sub-index.

The quality of life and labour attractiveness sub-index has the lowest coefficient of variability, defined as the ratio of the standard deviation to the mean. In other words, provinces scored more. similarly on this dimension compared to other sub-indexes. However, despite this and the fact that—with the exception of Kocaeli—none of the following are among the top five in the ranking, İstanbul accounted for 22.3% of employment growth in the country between 2019 and 2023, followed by Ankara (7.9%), İzmir (3.9%), and the TR42 region (9.3%), which includes Kocaeli, Sakarya, Düzce, Bolu and Yalova. In 2023, these eight provinces hosted 35.4% of the population and 38.8% of total employment. This suggests that, despite offering appealing living conditions for the labour force, many provinces continue to struggle in attracting investment and generating employment. The name given to this index refers to characteristics typically sought by workers in technology-oriented jobs. Both other indexes in this area and interviews with employees and employers in the tech sector have shown that factors such as wages, access to services (like education and healthcare), and ample opportunities for social interaction play a key role in labour force location choices. The index is structured similarly to SEGE; however, as illustrated in Figure 29, the correlation between the two is relatively low. In fact, among the five sub-indexes, this one shows the weakest correlation with provincial SEGE scores, which are calculated based on district-level data.

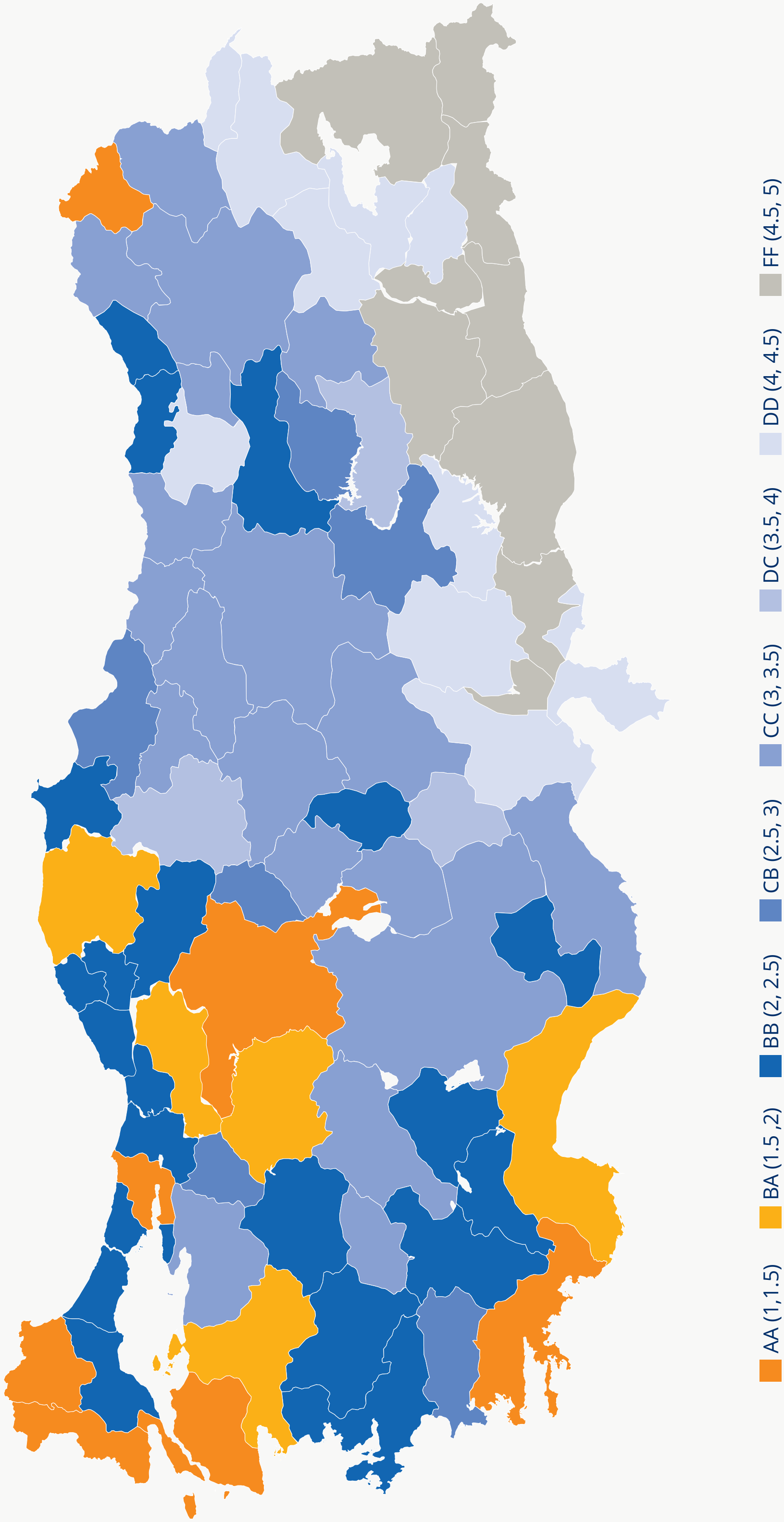
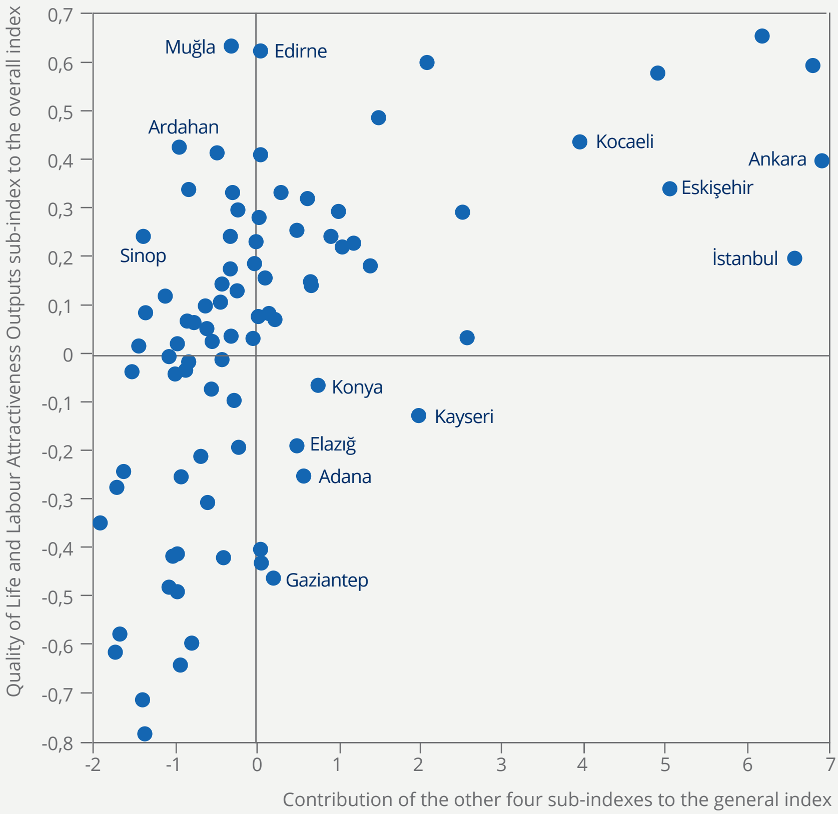


Figure 28. ASO-ILTEK Quality of Life and Labour Attractiveness Sub-index Average Grades

Figure 29. Relationship of Quality of Life and Labour Attractiveness Sub-Index with Other Sub-Indexes a



*Source: Republic of Türkiye Ministry of Industry and Technology, TEPAV calculations. *Provincial scores – calculated as the weighted averages of SEGE district 2022 index scores with district populations – are rescaled to between 0 and 1 using the min-max method. In the plotted sub-index score-SEGE scores, the axes are cut at the mean scores and are 1 standard deviation above the mean.*

One of the reasons for this situation is that the quality of life and labour attractiveness of provinces such as Ankara, İstanbul, Gaziantep and Bursa are well below their socio-economic development levels.

In Muğla, where quality of life and labour force attractiveness are highest, the contribution of this sub-index to the overall index is 188 percent, although it lags behind in terms of technological development. It is worthy of note that the contribution of this sub-index to the general index is above 80 percent in such other provinces as Edirne and Çanakkale, demonstrating their potential to attract qualified human resources if they are guided with the right industrial policy.

Considering that the main factor of production that will enable the technological transformation of provinces is labour, increasing the labour attractiveness of provinces should be considered of primary importance for both technological development and regional development. The fact that Türkiye's three largest provinces and a few provinces around them are the main providers of employment suggests that production and investments in Türkiye are concentrated in a narrow area. If this structure is to be maintained, Türkiye's ability to increase its income levels and sustain its growth will be realised only through the growth of İstanbul, Ankara and İzmir. Another possibility is to reduce the regional inequality in labour attractiveness and in most other areas, and to support different regions in contributing to national growth.

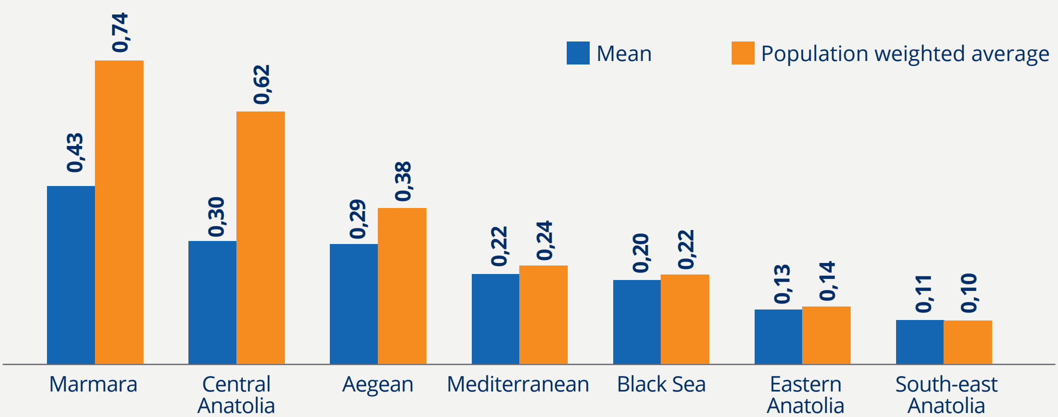
CONCLUSION AND POLICY RECOMMENDATIONS

> If Türkiye is to achieve its technological transformation goals, its talent management strategies and regional development policies need to be restructured.

The findings of the report show that the global economy is being shaped rapidly by the digital and green transformations, presenting both opportunities and challenges for Türkiye. The main hurdles faced by Türkiye on its technological transformation journey are its existing regional disparities, its inadequate digital infrastructure, its low technological intensity and its limited R&D. It is worthy of note that while some of Türkiye's provinces have significant potential in terms of technological development, this potential is not equally spread across the country.

The main finding of the report is that significant differences exist in provincial technological development. Ankara and İstanbul, which are included among WIPO's global innovation clusters, differ significantly from other provinces in terms of their technological development. As can be seen from Figure 30, the level of technological development of different provinces is actually a reflection of the regional inequality. The high ASO-ILTEK scores of Ankara and İstanbul, which have high population densities, play an important role in the prominence of Marmara and Central Anatolian regions. However, the fact that the provinces of the Marmara Region other than İstanbul have above average index scores differentiates it from other regions. The results show further that there is a high dependence on Marmara in the field of technology and in the economy in general. Apart from Marmara, Central Anatolia, and the Aegean, the similarity between the average and population-weighted average scores of the regions suggests that these regions comprise provinces which lag in technological development and do not differ significantly from one another.

Figure 30. ASO-ILTEK Average Results by Geographical Regions in Türkiye



The second important finding is that Türkiye has technology belts that are suitable for the implementation of a technological development strategy. The İstanbul-Kocaeli and Ankara-Eskişehir belts, as the four provinces with the highest overall index scores, can be considered the leading candidates for technological transformation and development. When the sub-indexes of the two belts are analysed in detail, it can be seen that the İstanbul-Kocaeli belt stands out in terms of its digital infrastructure, while the Ankara-Eskişehir belt scores high in terms of its research and innovation capacity and technological outputs. In the other two areas, these two belts were close to each other and had high values, indicating which areas should be targeted in generational-based policies. Moreover, the fact that Ankara and İstanbul are Türkiye's most technologically advanced provinces but lag behind in international indexes points to a need to implement

> It is worthy of note that İstanbul, which ranks second in the ASO-ILTEK ranking, ranks fourth in terms of research and innovation capacity with a score that is 57 percent that of Ankara's.

specific policies if these provinces are to compete on a global scale and move to a higher category.

By developing policies that reduce the gap between Ankara and İstanbul and its international counterparts and prioritising the development of provinces that lag behind in high-tech can increase Türkiye's competitiveness in the technological field.

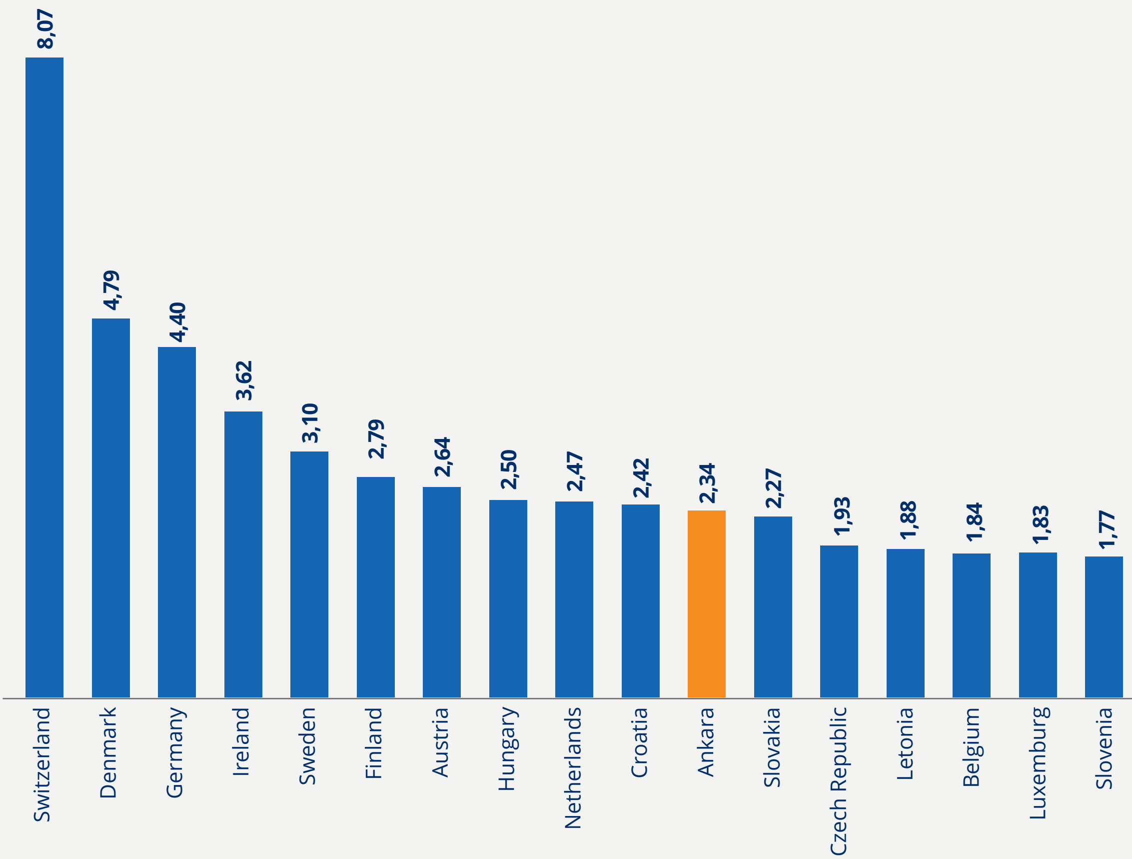
It is also important that province-level incentive and support mechanisms prioritise the differences between provinces and the areas in need of development in each province. For example, İstanbul, which takes second place in the ASO-ILTEK index, ranks fourth in terms of its research and innovation capacity with an index score that is 57 percent that of Ankara's. Furthermore, İstanbul, which ranks 24th in quality of life and labour attractiveness, must tackle its low research and innovation capacity while addressing the challenges of low quality of life linked to its high population density.

Although the sectoral structures of provinces such as Bursa and Kayseri lag far behind those of Ankara and İstanbul, their technological outputs are close to those of the two provinces, which has been attributed to the importance they attach to R&D and creative outputs in the traditional sectors. In such provinces, the use of incentives that encourage investments in the high-tech sectors are considered to be effective.

> Although the sectoral structures of provinces such as Bursa and Kayseri lag behind those of Ankara and İstanbul, they are close to these provinces in terms of their technological outputs, such as in industrial design and utility models.

A new clustering strategy can be implemented in Türkiye that takes into account the specific competences of different provinces and the existence of potential technology generations. Clustering policy in Türkiye developed in the late 2000s and early 2010s.

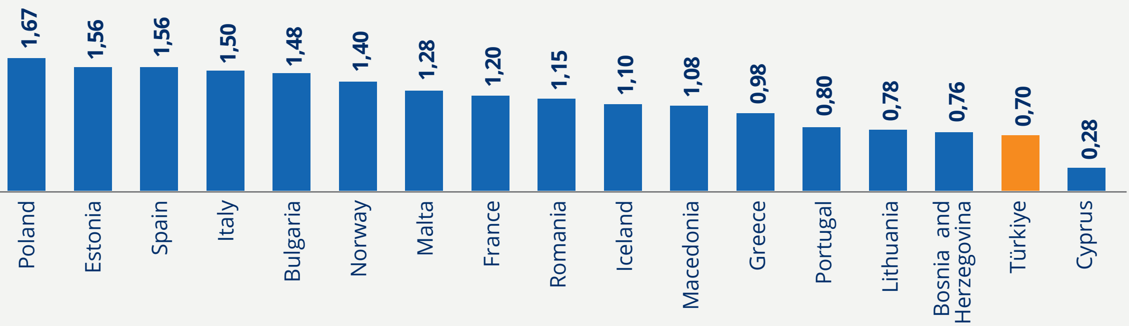
Figure 31. Share of Enterprises Operating in High-tech Fields in the Manufacturing Sector (%, 2022)



Source: Eurostat, TÜİK.

In particular, the UR-GE project support, initially administered by the Ministry of Economy and later by the Republic of Türkiye Ministry of Trade, has played a key role in supporting cluster formation in Türkiye. However, this support has primarily functioned to promote exports. While companies concentrated in certain regions and/or sectors have taken the first steps towards clustering as a result of these supports, the provision of advanced clustering support by different public institutions, especially the Republic of Türkiye Ministry of Industry and Technology, has not become widespread. Horizontal and vertical cooperation, risk sharing and cooperative competition among companies has not developed at the desired level in most clusters. It has not been possible to measure the input-outputs, mapping, the network behaviours of clusters, or the benefits and impacts of acting together. New models and supports need to be developed to promote clustering in Türkiye from a different direction, as acting together will make it possible for SMEs with scarce resources to improve their global competitiveness. It is hoped that a new clustering approach and new regional competitiveness strategies can be developed under the guidance of this index study.

> According to TÜİK data, the share of enterprises operating in high-technology fields within the total number of manufacturing sector enterprises in Türkiey increased from 0.41% in 2012 to 0.7% in 2022.



Although there has been a significant increase in the number of high-tech enterprises in Türkiye over the last 10 years, their share in the total number of enterprises is still low. According to TÜİK data, the share of enterprises operating in high-technology fields within the total number of manufacturing sector enterprises in Türkiey increased from 0.41% in 2012 to 0.7% in 2022. However, as of 2022, all European countries with available data—except Cyprus—have a higher rate than Türkiye. In Ankara, as the province with the highest high-tech enterprise density in Türkiye, this ratio increased from 1.06 percent in 2012 to 2.34 percent in 2022, placing Ankara in 11th place among all European countries, as can be seen in Figure 31. In 2022, the share of high-tech companies in the total number of manufacturing enterprises was above 1 percent in only five of the 81 provinces in Türkiye. When determining entrepreneurship policies in the field of high-tech, it is important to evaluate the capacity of these five provinces.

> Tailored and differentiated public support schemes should be designed and implemented for innovative enterprises that are fast-growing and/or have high growth potential.

The incentive mechanism should be adjusted to increase the density of high-technology enterprises and R&D expenditures. According to World Bank data, the ratio of R&D expenditures to GDP is 1.4 percent in Türkiye, compared to 2.9 percent in high-income countries, 2.1 percent in upper-middle-income countries and 2.6 percent globally. In Türkiye, public institutions such as TÜBİTAK and KOSGEB provide R&D support, mirroring much of rest of the world in the provision of R&D support essential for the realisation of high-risk and high-technology R&D projects amid high market fluctuations. The provision of such support in Türkiye is widespread and inclusive. When the history of R&D supports is examined, it can be seen that these supports are allocated based on a project application and evaluation process that distinguishes between start-ups, SMEs and large companies, in accordance with the support programme. For instance, at the company level, neither the technological maturity of the applicant company nor the specific technological capabilities to be enhanced through the proposed R&D project are systematically monitored. Furthermore, the province, region and technological level of the companies applying for R&D have little weight in the applied criteria. The efficient and effective allocation of resources can thus be ensured through the addition of such variables as region, technology level, productivity and R&D efficiency to the support criteria. To this end, the entire national industrial R&D support system, especially those operated by TÜBİTAK and TEYDEB, needs to be revised and modelled.

The effectiveness of public support and incentive mechanisms should be increased and these mechanisms should be restructured to reward criteria such as productivity growth and technological maturity. In one suggested approach, a certain proportion of the incentives could be allocated to fast-growing or innovative companies with growth potential, while performance-based incentives could be applied to enterprises investing in technology utilisation, innovation capacity and sustainable production methods. Such an approach will both increase the competitiveness of companies and ensure the more efficient use of resources. Furthermore, a monitoring and evaluation system should be developed to measure increases in productivity and the growth potential of companies, and to evaluate these indicators as incentive criteria. Focusing on companies with rapid growth potential will have a leverage effect on the transformation of the Turkish economy and accelerate the construction of a high value-added production structure.

To increase the effectiveness of incentives, it is important to carry out impact and needs analyses before implementation as part of the process and to monitor implementation. Factors such as the age, scale, sector, technological maturity and the applied procurement processes of enterprises influence the types and amounts of


METU Micro-Electro-Mechanical Systems Research and Application Centre (MEMS) / Ankara

incentives offered. An incentive model that does not take into account such criteria may lead to an inefficient use of resources. For example, current incentive mechanisms do not take into account the need for non-cash support in young enterprises operating in high-tech manufacturing and service sectors. On the other hand, establishing support systems that include effective monitoring and evaluation procedures and criteria for implementation processes can increase the flexibility and inclusiveness of incentives.

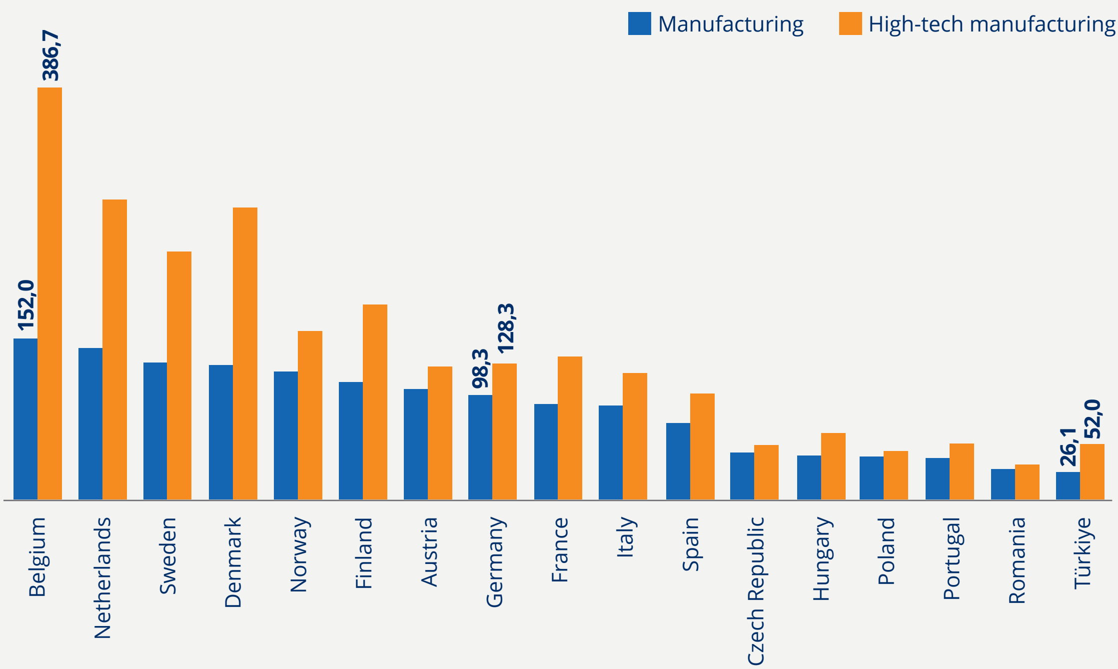
Türkiye needs a local and global value chain-oriented policy design to resolve the problem of low productivity in industry and the economy in general. As shown in Figure 32, Türkiye's value added per employee significantly lags behind that of European nations. The ratio of average value added per employee in Türkiye to the German average is 26.5 percent for manufacturing in general and 40.6 percent for the high-tech manufacturing sectors. These results indicate that as the technology intensity of the sectoral structure increases, average productivity in Türkiye will also increase, but within the same sector, there are significant productivity differences with the developed economies. To resolve this problem, companies need to develop competences in the high value-added links in the value chain and find a place for themselves.

Our companies generally lack the necessary R&D, technological competence, design and branding capabilities. The methods to be developed by applying the Global Value Chain approach will allow a better analysis of Turkish industry.

Different policies and practices should be developed for generations with technology potential and their successors. The transformation of technology belts such as Ankara-Eskişehir and İstanbul-Kocaeli into innovation-oriented economies should be ensured by taking advantage of their high product diversity and technological sophistication, while provinces such as İzmir, Bursa and Kayseri should be supported with qualified diversification-oriented policies that will allow them to become more competitive in the production of complex products. For other provinces, it is important to eliminate the deficiencies that reduce productive capacity, investments and labour force attractiveness. All of the above policies should be based on such concepts as productivity and R&D efficiency.

Making Türkiye's technology development zones more effective in the production of high-tech products and services will be effective in securing Türkiye's exit from the middle income trap. Although Türkiye's R&D expenditures have increased significantly over the last 20 years, they remain below the OECD average, and the effects of such expenditures on productivity and exports have to date been limited.

Figure 32. Manufacturing Value Added per Employee in Selected* European Countries



*Source: Eurostat, TÜİK. *Countries generating more than €20bn of manufacturing value added in 2022.*

Ensuring product and market diversification in technology-intensive sectors: To reduce the dependence on certain regions and to expand access networks, it is important to review the existing trade agreements so as to facilitate access to foreign markets and to protect domestic industry, and to consider this issue in all new agreements.

> A new technopark model that will strengthen the link between R&D and exports and in which technology-based initiatives work interactively with industrial companies should be designed.

A detailed industry and service inventory study should be conducted to support the data-driven policy design. Furthermore, an inventory of the technological products manufactured in Türkiye is necessary for the management of the highly diversified industrial product structure. Instead of sector prioritisation approaches that apply taxonomies based on international data on a country-by-country basis, an inventory study is required that takes into account Türkiye's provincial-sectoral-scale differences to identify the optimum focal points of policies and incentives. It should not be forgotten that the twin transformation is essentially a technological transformation that is affected by both production processes and technologies. If the spread of the domestic production of new technologies, throughout the economy is not developed based on an appropriate strategy, a new structural current account deficit will develop in Türkiye in the medium–long term. To eliminate this risk, the proposed inventory study should identify gaps in the value chain and technologies in Türkiye, and identify the provinces/districts and companies that can contribute to the closure of these gaps. It will thus be possible to design, implement and monitor new wide-reaching industrial policies under the guidance of the ASO Technological Development Index of Provinces together with the outputs of such an inventory study.

To support academia and other research organisations in carrying out detailed regional or provincial studies, the production of data at these levels should be increased, taking into account the global transformation. It is also important for the government, at both local and central levels, to increase open data applications. To support the global transformation process, a data-driven approach is needed to understand local and regional dynamics, to ensure the effective use of resources and to guide strategic decisions. In particular, the ability of academia and research institutions to conduct detailed analyses at the regional or provincial level depends on increasing access to data and improving data quality. In this context, the following recommendations, based on their successful implementation in other countries, should be taken into consideration:

- **Increasing Data Production at Regional, Provincial and District Levels:** TÜİK should produce more detailed socio-economic data at a provincial level based on regularly updated indicators. In addition, data sets specific global transformation areas (e.g. digital and green transformation, demographic changes) should be developed at district, provincial and regional levels. As an example, in Germany, the Federal Statistical Office provides comprehensive state-by-state datasets on the labour market, digitalisation, innovation capacity and environmental indicators, which support efforts in the country to develop strategies to address regional development gaps. Similarly, in Türkiye, data should be produced at the provincial and regional levels to monitor global trends such as digital and green transformation.

- **Dissemination of Open Data Applications:** Both central and local governments should apply open data policies to support transparency, accountability and data-based decision-making. All municipalities in Türkiye should create data sets covering the municipal budget, service quality, and environmental and social indicators, and make them available through open data portals. The central government should establish a comprehensive open data platform containing country-wide strategic data. The openness and accessibility of these data will facilitate regional analyses and the development of data-based policies. For example, the "data.gov.uk" platform in the United Kingdom and the "data.gov" platform in the United States provide open access to the data collected by public institutions, making them available to researchers and the general public. Türkiye can follow a parallel approach by increasing its "open data" capacity, thus supporting data-driven decision-making in regional and local governments..

> "The quality and diversity of the data shared with the public should be increased to support evidence-based policy processes."

- **Promoting Data Production and Open Data Use in Local Governments:** To increase the data collection and analysis capacity of local governments in Türkiye, funding can be provided by the state and incentives can be provided to local governments for data-driven projects. Such incentives can target regional projects related particularly to the digital transformation, the environment and sustainability. Furthermore, local governments can be encouraged to contribute to national policy-making process by integrating the data they acquire with central databases. An example of such an approach can be seen in Canada, where local government provides funding to municipalities through the Open Data Incentive Programme, supporting the development of data collection and open data projects. A similar practice can be supported in Türkiye through the provision of incentives to provincial governments and district municipalities.

- **Cooperation with Academia and Research Organisations:** Regional databases can be expanded by local governments and TÜİK conducting joint projects with universities and research centers. Providing academic institutions with open access to data can help Türkiye develop stronger policies related to of regional and global development. As an example of such an application, Australia's Regional Data Hub supports data sharing between universities, local governments and government agencies, encouraging research and the development of regional policies.

> Policies targeting improvements in quality of life should be developed to reduce the brain drain, and to attract qualified human resources to Türkiye by improving working conditions.

It should not be forgotten that the main factor contributing to the technological transformation is labour; as such, Türkiye's general and regional labour attractiveness should be increased with this in mind. According to TÜİK statistics for 2023 on the brain drain following higher education, 17.9 percent of Türkiye's molecular biology and genetics graduates, 9.1 percent of its electronics engineering graduates, 8.4 percent of its computer engineering graduates and 7.8 percent of its software engineering graduates migrated abroad between 2008 and 2017. It should not be forgotten that most of those who opt to migrate abroad are well qualified and have the highest employability levels. In this context, the differences between provinces in terms of their ability to attract talent, as implied also by the quality of life and labour force attractiveness component of the ASO Technological Development Index of Provinces, should be taken into account. The expectations of the talents that will ensure the technological transformation of the Turkish economy from entrepreneurs, provinces and the country should be analysed, and based on the results, a national talent management strategy should be developed. On the other hand, if Türkiye is to reach a high income level, to achieve sustainable growth and to retain its qualified human resources, a mechanism that takes into account large provinces such as İstanbul, Ankara and İzmir should be established.

As in other areas, it is necessary to develop approaches to the reduction of regional inequalities in the field of labour attractiveness.

Türkiye is obliged to complete its Twin Transformation, as frequently mentioned in the report, and as part of its commitments to such global conventions as the Paris Agreement. As such, Türkiye should draw up a well-designed strategic roadmap to steer efforts to achieve its declared net zero emission target for 2053. The necessary plans should be put in place to support the realisation of this transformation in a fair manner, ensuring nobody is left behind. For example, the phasing out of coal, the necessary investments into renewable energies and the sources of financing required to meet the ever-increasing demand for energy should be discussed with broad stakeholder participation. Regional competences and priorities should be prioritised in these discussions and future plans, and the province-based technological development index proposed in this report can serve as a helpful guide in this regard.

To accelerate Türkiye's technological development and to support industrial production in increasing Türkiye's global competitiveness, innovative approaches should be applied to the design of new industrial spaces and the transformation of existing industrial zones. Accordingly, new industrial zones should be planned with an approach that focuses on digitalisation, green transformation, technology-based entrepreneurship and high value-added production. In particular, industrial spaces should be designed with smart infrastructures and increased energy efficiency, and with the circular economy in mind. Furthermore, these zones should be integrated with universities, R&D centres and technology development zones to support the development of an ecosystem focused on knowledge and innovation. Under the leadership of the state, and in cooperation with local government, the private sector and non-governmental organisations, such processes should be supported and incentive mechanisms should be adapted to meet the defined targets. In this way, Türkiye's industrial structure will be able to respond not only to the needs of today, but also those of the future.

> "According to TÜİK data, 8.4 percent of Türkiye's computer engineering graduates and 7.8 percent of its software engineering graduates have migrated abroad."

Among the main factors hindering Türkiye's technological and economic transformation are a lack of skills and losses of talent. To overcome this problem, a Skills Needs Map should be prepared at a national level taking into account sectoral and scale differences. Such a map can support the identification of the current and future needs of the business world, and reveal which areas are affected by a skills gap. Such a map can contribute to the development of a comprehensive National Talent Strategy that can steer the development of policies aimed at improving quality of life and wage levels, as well as efforts to create an internationally competitive ecosystem that can attract and retain high talents and skilled labour, and prevent outward migration. Specific incentive programmes and mission-oriented policies targeting digital and green skills should form the cornerstones of this strategy.

The education system should be restructured to support Türkiye's skills transformation. The current system falls short of meeting the needs of the business world, and so effective cooperation should be established between educational institutions and the private sector to harmonise curricula with the market needs. The quality of vocational education should be improved, young people's interests in such fields should be encouraged and lifelong learning opportunities should be extended. In addition, a new generation of education programmes should be designed to teach the skills required for digitalisation and the green transformation process, focusing on both basic skills and technological specialisations. As Türkiye's education system evolves to meet the needs of the future, it should provide the necessary infrastructure for individuals to find work in high value-added jobs.

> "A strategic road map should be prepared to ensure the talents and skills raised in our country meet the needs of the business world, involving the creation of a talent inventory."

In Türkiye's skills transformation process, it will not be enough to improve the competencies of the labour force, as new models will need to be developed to ensure the transformation of employers and the industrial structure. Even if the necessary talent development programmes are successfully implemented, new mismatch problems may arise if the quality of the jobs, working conditions and work environments offered by employers do not meet the expectations of these talents. To overcome this problem, a comprehensive strategy focusing on the transformation of industrialists should be implemented. Industrial policies should be restructured to encourage high value-added production and innovative business models; and financial and technical support mechanisms should be developed to aid employers in their adaption to the digital and green transformation processes. In addition, flexible, innovative and employee-friendly business models should be adopted that strengthen employer-employee relations in industrial zones. Awareness programmes for the private sector should encourage employers to improve their talent management and workplace standards, thus creating a harmonious and sustainable ecosystem for both the workforce and employers. This transformation will not only reduce the skills mismatch, but will also increase Türkiye's international competitiveness.

In conclusion, the results and evaluations of the ASO-ILTEK study will contribute considerably to the efforts of our country's technological ecosystem to compete with the developed nations, and will serve as a guide for strategic decision-making. Carrying out such a study every year and sharing the results and comparisons with the public will support the development of national, regional and local policies, and thus contribute to the technological development of our country.

ANNEXES

ANNEX 1. RESEARCH METHODOLOGY

In this section, the content of the variables used in the index, their meaning, the data sources and frequencies, and the relationship of the data with other variables are discussed in a detailed and methodological manner. In addition to the explanatory power of the variables and the conceptual framework, detailed information has been provided on the index calculation method and the statistical techniques employed.

	Data Sources	Year	Unit
Sectoral Structure Variables			
Share of high-tech manufacturing and services in total number of enterprises	TÜİK	2022	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	SSI, TÜİK	2023	Per thousand
Research and Innovation Capacity Variables			
Number of R&D centres per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2023	Number
Number of Technology Development Zones per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2023	Number
Number of Design Centres per 100,000 enterprises	Republic of Türkiye Ministry of Industry and Technology, TÜİK	2023	Number
Number of publications in universities	ULAKBİM	2023	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	2023	Number
Number of academicians in technology-related fields per 1,000 enterprises	YÖK, TÜİK	2023	Number
Number of companies receiving industrial R&D support per thousand manufacturing enterprises	TÜBİTAK, TÜİK	2023	Number
Amount of industrial R&D support per thousand enterprises	TÜBİTAK, TÜİK	2023	TRY
Number of companies receiving industrial entrepreneurship support per thousand manufacturing enterprises	TÜBİTAK, TÜİK	2023	Number
Amount of industrial entrepreneurship support per thousand enterprises	TÜBİTAK, TÜİK	2023	TRY

	Data Sources	Year	Unit
Digital Infrastructure Variables			
Broadband subscribers per hundred inhabitants	ICTA, TÜİK	2023	Number
Share of fibre broadband subscribers	ICTA, TÜİK	2023	Percentage
Number of mobile broadband subscribers per hundred inhabitants	ICTA, TÜİK	2023	Number
Number of 3G and 4.5G connected mobile phones per hundred people	ICTA, TÜİK	2023	Number
Technology Outputs Variables			
Number of patent registrations per thousand people	Türk Patent, TÜİK	2023	Number
Number of utility model registrations per thousand people	Türk Patent, TÜİK	2023	Number
Number of design registrations per thousand people	Türk Patent, TÜİK	2023	Number
Exports of high-tech per enterprise in the manufacturing sector	TÜİK	2023	USD
Quality of Life and Labour Attractiveness Variables			
Student-Friendly University Province Index	ÜniAR	2023	Skor
Average net migration rate	TÜİK		Per thousand
Number of cinema seats per hundred inhabitants	TÜİK	2023	Number
Number of theatre seats per hundred people	TÜİK	2023	Number
Average wage in the private sector (PPP-adjusted)	SSI, TÜİK	2023	TRY
Male-female average wage ratio	SSI	2023	Percentage
Average wages of women (PPP-adjusted)	SSI, TÜİK	2023	TRY
Unemployment rate	TÜİK	2023	Percentage
Employment rate	TÜİK	2023	Percentage
Shopping and trade area per thousand inhabitants	Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, TÜİK	2024	m^2
Leisure, culture and sports facilities per thousand inhabitants	Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, TÜİK	2024	m^2
Number of social hubs per 100 persons over 18 years of age	Republic of Türkiye Ministry of Agriculture and Forestry, TÜİK	2024	Number
Number of specialised physicians per hundred inhabitants	TÜİK	2022	Number
Number of students per classroom in primary education	TÜİK	2022	Number
Number of students per teacher in primary school	TÜİK	2022	Number
Net preschool enrolment rate for 3–5 age group	TÜİK	2022	Percentage

1.1. Variables Used in the Index

1.1.1 Research and Innovation Capacity Sub-Index and Variables

The research and innovation capacity sub-index measures the research and development activities and innovation potential, as well as the infrastructure and human resources required to support such activities, for an assessment of the level of technological development of the provinces. The OECD's Innovation Policy Reports mention the critical role of R&D centres, universities and technology development zones in the innovation ecosystem (OECD, 2015). The index considers the number of R&D centres, technology development zones and design centres to be representative of the R&D and innovation infrastructure. R&D and design centres and technology development zones contribute to the innovation infrastructure and are a measure of the cooperation opportunities of the region.

Academic research and education infrastructure is included in the sub-index through the publication and university project performance index, as well as the number of students and academicians working in technological fields (STEM). The number of university publications and projects reflects the intensity of academic research activities. The number of students and academicians in technology-related fields is used as an indicator of both qualified labour potential and knowledge accumulation. Finally, R&D and entrepreneurship supports that encourage companies to innovate and increase their financial capacities are also included in the sub-index as capacity indicators.

- **Number of R&D Centres per Enterprise:** R&D centres are departments in which companies develop new products, services and processes. The number of R&D centres per enterprise is an indicator of the level of investment in R&D among companies in a region. Cohen and Levinthal (1990) claim that R&D activities increase the "absorptive capacity" of companies, allowing them to innovate through the effective use of external knowledge. Asheim and Gertler (2005) state that the density of R&D centres in a regional innovation system positively affects innovation performance, and so the higher the ratio, the greater the innovation capacity and technological development of the region.

- **Number of Technology Development Zones per Enterprise:** Technology development zones are ecosystems that encourage cooperation between universities, research institutions and companies, and that facilitate knowledge transfer. Phan and Siegel (2006) claim that technology parks increase university-industry cooperation and contribute to regional economic development.

- **Number of Design Centres per Enterprise:** Design centres support the innovative and user-oriented design of products and services, and as such are important components of the innovation ecosystem. Gemser and Leenders (2001) suggest that the integration of design into the product development process positively affects company performance, while Verganti (2009) states that design-oriented innovation increases the competitiveness of companies. In this regard the number of design centres per enterprise is an indicator of the creative capacity and competitiveness of the province in question.

- **Number of Publications of Universities in the Province:** The number of publications of a university is a measure of the intensity of its academic research activities and its contribution to scientific knowledge. A high number of publications points to high knowledge and innovation potential. King (2004) claims that scientific publications contribute to technological progress and economic growth, while Mansfield (1991) states that academic research contributes significantly to industrial innovation.
- **Number of Projects of Universities in the Province in the Last 5 Years:** D'Este and Patel's (2007) study of the United Kingdom reports that academic projects increase regional innovation capacity. This variable, as a reflection of the dynamism of the innovation ecosystem of a province, is included in the sub-index as an indicator of applied research activities and university-industry cooperation.
- **Number of Students in Technology-Related Fields per 1,000 Enterprises:** The number of students in technology and engineering fields in universities can be considered an indicator of the size of the future technological talent pool. Qualified human resources are indispensable for innovation and technological development (Nelson and Phelps, 1966) and regions with high concentrations of highly educated people have a higher potential to produce innovation (Florida, 2002).
- **Number of Academicians in Technology-Related Fields per 1,000 Enterprises:** The number of academics in technology-related fields in universities reflects the teaching and research capacity of the higher education institutions of a region in the fields of technology and engineering. The size and quality of the academic staff affect the research capacity of universities and the potential for cooperation with industry (Etzkowitz and Leydesdorf, 2000).
- **Number of Companies Receiving R&D/Entrepreneurship Support per Manufacturing Enterprise:** The number of companies receiving R&D support is an indicator of the extent of financial support provided by the government and to institutions to encourage innovation, while the number of companies receiving entrepreneurship support is an indicator of the extent to which innovation is encouraged and supported. Although there is no clear information on the impact of these supports in Türkiye, David, Hall and Toole (2000) claim that public R&D support encourages private sector R&D expenditures. As such, it can be said that the high share of those who receive such supports among the manufacturing sector companies increases the economic dynamism and innovation capacity of the province, thus contributing to its technological development. To represent this,

the share of R&D support recipients and the share of entrepreneurship support recipients among the manufacturing enterprises in the province are included in the sub-index as two variables.

- **Amount of R&D/Entrepreneurship Support per Manufacturing Enterprise:** The amount of R&D and entrepreneurship support shows the extent to which the manufacturing sector in the province invests in these activities, and the level of support provided for such activities. The high level of support was considered to reflect the financial health of the province's technology and innovation ecosystem. Indeed, Hall and Lerner (2010) emphasise that financial resources are critical for the sustainability of R&D and innovation. As with the number of companies receiving support, the amount of support per enterprise is represented by two variables.

As a result of the principal components analysis applied to the 11 variables in the research and innovation capacity sub-index, four components with eigenvalues greater than 1 were identified. The first principal component explains 45.5 percent of the variability in the variables, while the first four components account for 83.5 percent of the total variability. Considering the weights of the variables in each component and the variability ratios explained by the components, it can be understood that leading variables in this sub-index are the number of students and academicians in technology related fields per enterprise, the number of companies receiving industrial support per manufacturing enterprise and the total amounts of this support.

1.1.2. Digital Infrastructure Sub-Index and Variables

Castells' (1996) "Network Society" concept explains how digital communication networks contribute to the transformation of the economic and social structure. Bertschek, Cerquera and Klein (2013) report that high-speed internet increases the innovation activities and productivity of companies, while Kim, Kelly and Raja (2010) claim that access to a fibre optic infrastructure accelerates the adoption of advanced digital services and applications. The Digital Infrastructure sub-index, designed in line with these findings, measures the digital infrastructure and connectivity capacities of provinces while assessing their technological development. This sub-index focuses on the prevalence, quality and accessibility of information and communication technologies (ICT) and infrastructures, and comprises two variables, being fixed broadband and mobile broadband access.

- **Number of Broadband Subscribers per Capita:** The number of broadband subscribers per capita indicates the prevalence of fixed broadband internet access in a region. Broadband internet provides businesses and individuals with easy access to digital services. This supports the growth of the digital economy, increases efficiency and allows new business models to emerge. Qiang, Rossotto and Kimura (2009) claim that broadband penetration has a positive impact on economic growth, reporting that a 10 percent increase in broadband access can increase GDP growth by 1.21 percent. Koutroumpis (2009) suggests that access to broadband infrastructure encourages innovation and increases the competitiveness of enterprises.

- **Share of Broadband Subscribers with Fibre Connection in the Number of Broadband Subscribers:** The proportion of fibre connections indicates the speed and quality of the internet infrastructure in a region. Fibre optic connections allow the deployment of high-tech and applications (e.g. cloud computing, big data analytics, Internet of Things) by providing high-speed and low latency internet services, thus contributing to innovation capacity and competitiveness.

- **Number of Mobile Broadband Subscribers per Capita:** The mobile broadband access allows people to access digital services while on the move, thus contributing to the reduction of the digital divide. The adoption of mobile technologies supports technological development. Donner (2008) claims that mobile technologies increase digital inclusion and expand economic opportunities in developing regions.

- **Number of 3G or 4.5G Mobile Phones per capita:** The number of 3G or 4.5G mobile phones per capita indicates the rate of adoption of advanced mobile communication technologies. The widespread use of such technologies providing high-speed mobile internet access increases participation in the digital economy. This facilitates the spread of innovation and the development of digital services. Shin and Park (2007) claim that the adoption of advanced mobile technologies encourages the development of innovative services and changes consumer behaviours; while Bohlin, Gruber and Koutroumpis (2010) report that advanced mobile technologies increase the variety and quality of the available digital services.

An examination of these four variables reveals a low correlation between fibre subscriber density and other variables, while the correlation between the other three variables is high. The first principal component explains 70.3 percent of the variability presented by the four variables. The weights of the other three variables are in the range of 0.57–0.58, while the weight of the fibre subscriber density variable is 0.15.

1.1.3. Technology Outputs Sub-Index and Variables

The technology outputs of an economy are a tangible indication of its innovation level. Patents, utility models and trademark registrations are direct indicators of innovation activities. The OECD's Oslo Manual stress the importance of focusing on such outputs when measuring innovation (OECD, 2018). As such, the technology outputs sub-index includes the number of registrations related to innovation outputs, such as patents, trademarks, utility models and designs, and the high technology intensity of the province's exports. This sub-index assesses the conversion of research and development activities into economic value and technology production capacity.

- **Number of Patent Registrations per Person:** This variable indicates the intensity of innovative and original technological inventions in a region. Patents ensure the legal protection of technological innovations and secure returns on R&D investments. A region's patent registration rate is an indication of its technological creativity and innovation capacity. Griliches (1990) claims that patent data can be used as an indicator of technological change and innovation; while Jaffe and Trajtenberg (2002) state that patents facilitate the diffusion of technological knowledge and the acceleration of innovation.

- **Number of Utility Model Registrations per Person:** Utility models, as a measure of the intensity of practical and small-scale technological innovations, protect the innovations of SMEs and individual inventors, and are important in encouraging technological development in the grassroots. Kim and Lee (2015) state that utility model registrations increase the innovation capacity and competitiveness of regions.

- **Number of Design Registrations per Person:** Design registrations are an indication of the intensity of industrial design and aesthetic innovations in a region, and increase product differentiation and brand value by protecting innovations in product designs, and are a measure in particular of capacity and competitiveness in the creative industries. Von Stamm (2008) claims that design-oriented innovation increases the innovation capacity and market success of companies.

- **Exports of High-tech per Enterprise in the Manufacturing Sector:** Exports of high-tech per enterprise in the manufacturing sector indicate the capacity of companies in a region to offer high value-added and high-tech products to international markets, and are a reflection of its global competitiveness and technological leadership potential. Lall (2000) argues that exports of high-tech accelerate economic growth and are critical in increasing technological capacity, while Grossman and Helpman (1991) argue that exports of high-tech accelerate technology transfer and knowledge accumulation.

The correlation value between patents and utility model registrations per capita is 0.67, while the correlation of design registrations with these two variables is less than 0.5. On the other hand, while there is a correlation of 0.5 between high-tech exports per enterprise in the manufacturing sector and patent registrations per capita, the correlation with the other two variables is low. In the first principal component, which explains 57.3 percent of the total variability presented by these four variables, patent and utility model registrations per capita have a greater weight than the other two variables.

1.1.4. Quality of Life and Labour Attractiveness Sub-Index and Variables

Quality of life and labour attractiveness are vital for a region's ability to attract and retain highly skilled human capital. Florida (2002) claims that quality of life and access to cultural amenities in a region support innovation and economic growth. Variables representing areas such as labour market conditions, socialisation opportunities, tolerance levels, and access to education and health services were used in this component, as criteria sought by potential technology ecosystem employees for living and working.

- **Student Friendly University Province Index Score:** This variable measures how attractive a province is for students and the quality of university life. Student-friendly provinces offer a fertile environment for innovation and creativity on the strength of the young and dynamic populations who are attracted to the region, leading to an increase in university-industry collaborations. Florida (2002) states that provinces that attract the creative classes achieve greater economic growth and innovation.

- **Three-Year Average Net Migration Rate:** The Net Migration Rate is an important indicator of the attractiveness and liveability of a region. A positive net migration indicates the desire of people to settle in a region, attracted by the employment, education and living opportunities (Glaeser and Shapiro, 2003). This ensures the flow of qualified labour to the region and an increase in human capital. Saxenian (2006) claims that immigration and population mobility can have positive effects on innovation and entrepreneurship.

- **Cultural Facilities (Number of Cinema and Theatre Seats per Person):** Arts and culture play an important role in the innovation ecosystem (Scott, 2006). The proportion of cinema and theatre seats to a region's population is a key indicator of its cultural and social capital, indicating the accessibility of cultural activities and a greater quality of life. This can contribute to the attraction of a qualified labour force to the region and the vitality of social life. Glaeser, Kolko and Saiz (2001) claim that access to cultural and recreational facilities can contribute to the attractiveness and economic growth of a province. This parameter is represented by two variables.

- **Shopping and Commercial Area per capita:** The density of shopping and commercial areas is an indicator of the richness of economic activity and consumer opportunities in a region, improving the quality of life and attractiveness of the region as an attractive destination for skilled labour and consumers. Glaeser and Gottlieb (2006) claim that consumer services and shopping facilities increase the attractiveness and quality of life of provinces.

- **Recreational, Cultural and Sports Facilities per Capita:** The density of entertainment, recreation and sports facilities is a measure of the quality of life and social opportunities in a region. The presence of such facilities increases the attractiveness of a region by promoting healthy living and increased social interactions. Putnam (2000) states that social activities and common areas increase social capital and social health.

- **Purchasing Power Adjusted Average Daily Gross Wage in the Private Sector:** Competitive wage levels are critical for attracting and retaining skilled labour (Acemoglu and Pischke, 1999). The average wage in the private sector indicates the level of economic prosperity in a region and the attractiveness of the labour market. High wages attract qualified labour to the region and increase living standards. The Purchasing Power Parity (PPP) adjustment ensures that the real purchasing power of wages is reflected.

- **Male-Female Ratio in Average Daily Gross Wages:** Gender equality increases diversity and participation in the labour market (Blau and Kahn, 2000). The female-to-male average wage ratio is an indicator of gender equality and equal opportunities in the labour market. Regions with high rates of gender equality suggest a more inclusive and fair work environment. This variable is also considered a predictor of the tolerance level of provinces, and indicates the potential of a region to attract qualified female employees.

- **PPP-Adjusted Average Daily Gross Wages of Women:** The participation of women in economic life increases the total labour force potential (Goldin, 2014). High average wages increase the economic independence and social participation of women, supporting the inclusiveness and diversity of the region's labour market.

- **Employment and Unemployment Rates:** Low unemployment and high employment rates are indicators of economic stability and social welfare (Blanchard et al., 1992), and reflect the vibrancy of economic activity and the abundance of job opportunities in a region. High employment rates can facilitate the attraction of qualified labour to the region and the improvement of the quality of life.

- **Number of Social Hubs per 100 People Over 18 Years of Age:** The vibrancy of social life and the richness of entertainment opportunities in a region can be understood from the density of venues serving alcohol. The variable is included in the sub-index as a tolerance level indicator. It is thought that social hubs increase the social interactions and attractiveness of a region, and play an important role in meeting the social needs of the qualified labour force. Oldenburg (1999) states that social hubs, which he refers to as "third spaces", also strengthen social ties.

- **Number of Specialist Physicians per Capita:** The number of specialised physicians in a region indicates the quality and accessibility of health services in a region. A high physician density indicates a high quality of life and attractiveness level in a region. The quality of health services available is an important factor affecting the choices of labour forces and their families to move to a region. Bloom and Canning (2000) state that access to quality health services increases both quality of life and labour productivity.

- **Number of Students per Classroom in Primary Education:** The number of students per classroom is an indicator of the quality of education and educational facilities. Low student density indicates better education quality, affecting the regional preferences of families and supporting the training of a qualified labour force. Krueger (1999) claims that class size has a significant effect on student achievement.

- **Number of Students per Teacher in Primary School:** The number of students per teacher is an indicator of the quality of education and individual learning opportunities. Lower rates indicate that students can benefit more from individual attention and support. This supports the development of human capital and the training of qualified labour. Finn and Achilles (1990) claims that low teacher-student ratios increase student achievement and engagement levels.

- **Preschool Net Schooling Rate for 3–5 Age Group:** Early childhood education is critical for the development of cognitive and social skills (Heckman, 2006). Furthermore, the prevalence and quality of pre-primary education in a region is among the determining factors affecting the choices of families to locate to a region and the participation of women in the labour force. High preschool enrolment rates increase academic achievement and the quality of human capital in the long run, as well as labour attractiveness in the short run.

Five components with eigenvalues greater than 1 were identified in the principal components analysis applied to the 16 variables constituting the quality of life and labour attractiveness sub-index. The first five components account for 73.4 percent of the total variability, while the principal component explains 30.9 percent. Considering the weights of the variables in each component and the variability ratios explained by the components, it can be seen that unemployment and employment rates, cultural facilities, and the number of students per teacher and classroom are the leading determinant variables in this sub-index.

1.2. Statistical Techniques Applied in the Index Study

The ASO-ILTEK composite index uses 37 variables and five sub-indexes to measure the level of readiness of the 81 provinces in Türkiye for technological development. There is no missing data problem other than for the variable "average satisfaction of university students" under the quality of life and labour attractiveness sub-index. Since the provinces of the 6 February disaster zone were not included in UniAR's Student Friendly University Cities 2023 survey, the scores of these 11 provinces were obtained using the min-max rescaling method for 2022, multiplied by the maximum-minimum value difference in 2023, and the minimum score in 2023 was added to the obtained value.

In the first stage of the index construction, z-scores were obtained by subtracting the average of the in 37 variables of the 81 provinces from the value of the province, and proportioning the difference obtained to the standard deviation of 81 provinces. Z-scores were rescaled to a range of 0–1 using the formula $Z_{min\text{ - }max\ (i)} = \frac{Z_i - Z_{min}}{Z_{max} - Z_{min}}$ min-max method).

Next, the index was constructed in three stages. In the first stage, a principal component analysis was applied to the variables under each sub-index, and the scores of all components with eigenvalues greater than 1 were calculated. In the second stage, the sub-index score was calculated by averaging these scores weighted by the variance explained by the components to which they are connected. In the third stage, after the sub-index scores were again scaled to 0–1 using the min-max method, the five sub-indexes were subjected to principal components analyses. The variable obtained by scaling the score calculated from the first principal component obtained from this analysis between 0-1 is referred to as the Technological Development Index of ASO Provinces. Annex 2 provides a detailed description of both the principal component analysis method and the other analytical methods used in the study.

Statistical methods such as z-score, min-max rescaling and principal component analyses were used for the calculation of the index in the ASO Technological Development Index of Provinces study. Clustering methods such as Jenks Natural Breaks and K-Means were utilised to classify the provinces into groups according to their index scores. Detailed information on these methods is presented in this appendix.

Standardisation with Z-score

The Z-score measures the deviation of each observation from the mean in its distribution, and the magnitude of this deviation as a standard deviation. It is used to standardise the variables in a data set with a mean of 0 and a standard deviation of 1, thus making data from different scales comparable. This method reduces the effect of extreme outliers and facilitates meaningful comparisons between variables. The Z-score is calculated using the formula:

$$Z = \frac{x - Average}{Standard\ Deviation}$$

Min-Max Rescaling

This method is used to scale data to a specified range (usually 0 to 1), and is preferred due to its ability to ease the interpretation of data standardised by z-score, or to present index values within a limited range. The method draws the results into a certain range, making scaled values more understandable. Min-max rescaling is performed using the following formula:

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

For rescaling in the opposite direction when dealing with such variables as unemployment in which high levels indicate low performance, the formula is modified as follows:

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

Principal Component Analysis (PCA)

A PCA creates principal components by reducing the number of variables in multidimensional data sets. These components represent the maximum of the total variance of the data set. When constructing an index, it is used to minimise information loss by determining the common variance between variables, and to reduce the number of variables in the analysis. A PCA identifies the main elements by revealing the correlation structure in the data set, providing leaner and more interpretable components to the index study.

In the first stage, using the standardised data matrix, a covariance matrix of size C is calculated using the following formula: $C = \frac{1}{n-1} X_{standard}^{T} X_{standard}$ The covariance matrix details the relationships (covariances) between variables. High covariances indicate that the variables move together.

In the second stage, the eigenvalues (λ) and eigenvectors (v) of the covariance matrix are calculated, which is necessary for the determination of the basic components. The eigenvalues show how much each component explains the variance in the data, while the eigenvectors determine the directions of the components. The characteristic equation of the covariance matrix C is: $\det(C - \lambda I) = 0$. Eigenvalues $(\lambda_1, \lambda_2, \ldots \lambda_p)$ are obtained using this equation. The magnitude of each eigenvalue indicates how much the respective principal component explains the variance in the data set.

In the third stage, the eigenvalues are ranked and the first k components explaining a certain percentage of the total variance are selected. In this case $k \leq p$ If $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_p$ the first $\mathbf{k}$ eigenvalues represent the components that explain the highest variance in the data set.

In the fourth stage, the selected k eigenvectors $(v_1, v_2, \dots v_k)$, form the principal components, and new components are obtained by multiplying these eigenvectors with the standardised data matrix: : $Y = X_{standard} . V_k$. Here matrix Y is of size $n \times k$ and gives k principal component scores for each observation.

PCA simplifies complex relationships in the data set with independent principal components generated from the original variables. Since the first few principal components explain most of the total variance in the data set, using these components in the analysis will reduce dimensionality and make it more understandable. This method also reduces multiple collinearity problems by working with fewer dependent variables in cluster analyses or regression models.

Jenks Natural Breaks

The Jenks Natural Breaks clustering method identifies the lowest variance in each group by dividing the data into natural intervals, and is a classification method that maximises the differences between groups and similarities within groups. It is frequently used in geographical data analyses and social sciences, and is particularly suitable for the creation of homogenous groups by decomposing index values. In a clustering process, the minimum squares method is used to find the break points that minimise the variance of each class.

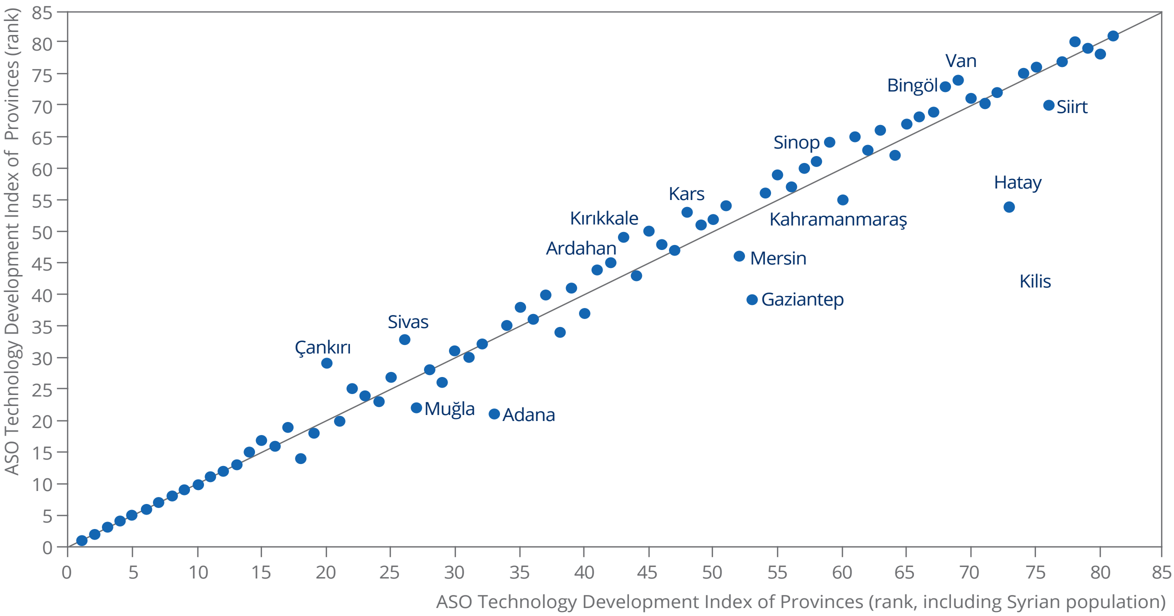
K-Means Clustering

The k-means algorithm divides the observation set into k clusters and aims to assign the closest mean point to each cluster, with the aim being to classify the data into homogeneous groups so that the units of analysis (provinces in the present study) can be classified based on their similarities. It is a powerful tool that allows a better understanding of cumulative structures, however the chosen k value directly affects the results. The algorithm is applied using the following steps: 1) Determine the number of clusters (k), 2) select k random centres, 3) Assign each observation to the nearest centre, 4) Update the cluster centres, 5) Repeat steps 3 and 4 until the clustering remains constant.

ANNEX 2. INCLUSION OF THE SYRIAN POPULATION IN INDEX BUILDING

An important point to be considered in both ASO-ILTEK and other province-based index studies is that most variables are proportioned to the population so as to control the size differences between provinces. Similar to the present study, the results obtained from TÜİK's Address Based Population Registration System are used for the provincial population, however, according to official records, as of 24 October, 2024 there are approximately 3.1 million Syrians under temporary protection in Türkiye, and this population is not homogenously distributed across the country. For example, in provinces such as Gaziantep, Hatay, Kilis and Şanlıurfa the share of the Syrian population in the total population of the province is above 10 percent. Since 12 of the 37 variables used in the present study are calculated as a ratio to the population, the inclusion of the Syrian population in the analysis can be expected to change the rankings. To overcome this, a version of the ASO Technological Development Index of Provinces including Syrian population was calculated using the same method. A comparison of the rankings obtained following this correction with the rankings created using the original values is presented in Figure 33.

Figure 33. ASO Technological Development Index Results of Provinces (Syrian Population



Note: Provinces below the 45-degree line are those whose ranking decreases once the Syrian population is included, while those above that line are those whose ranking increases.

When the Syrian population is included in the analysis, 19 provinces decrease in ranking, 40 provinces increase in ranking and the ranking of 22 provinces remains unchanged. As a result of the significant difference between the provinces with high technological development scores and the other provinces, the inclusion of the Syrian population has no effect on the 13 highest ranking provinces. It is worthy of note that nine provinces dropped more than 5 places in the ranking due to the Syrian population, including Kilis that dropped 31 places, Gaziantep that dropped 14 places, Hatay that dropped 13 places and Adana that dropped 12 places. Among the 9 provinces that rose more than 5 places are Çankırı, Sivas and Ardahan, which have risen 9, 7 and 6 places, respectively. Among the top 20 provinces in the main ranking, only Denizli experienced a significant decline, being ranked 14th based on its general index score, but 18th when the Syrian population is included. As can be seen in Table 4, while there are 8 provinces rated DC in the original index, no provinces have a DC ranking when the Syrian population is included in the analysis.

Table 4. ASO-ILTEK Index Results (Syrian Population Included)

Province	Letter Grade	ASO Technological Development Index of Provinces (score)	ASO Technological Development Index of Provinces (no.)	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour Attractive-ness (no.)
Ankara	AA	1,00	1	2	1	2	2	7
İstanbul	AA	0,91	2	1	4	1	5	24
Eskişehir	AA	0,83	3	4	2	8	1	11
Kocaeli	AA	0,71	4	3	3	11	7	6
İzmir	BB	0,52	5	5	7	5	11	13
Bursa	BB	0,49	6	10	9	17	3	48
Kayseri	BB	0,42	7	12	16	34	4	58
Sakarya	BB	0,41	8	19	10	26	6	27
Tekirdağ	CB	0,39	9	6	13	30	25	23
Karabük	CB	0,39	10	42	5	33	19	14
Düzce	CB	0,38	11	7	8	43	16	22
Manisa	CB	0,36	12	8	22	50	9	21
Antalya	CC	0,34	13	14	34	4	41	10
Trabzon	CC	0,34	14	24	11	12	37	29
Edirne	CC	0,33	15	17	29	13	72	2
Isparta	CC	0,32	16	26	12	32	23	17
Bolu	CC	0,32	17	20	20	37	17	9
Denizli	CC	0,31	18	21	19	21	22	28
Konya	CC	0,30	19	31	24	45	8	56

Table 4. ASO-ILTEK Index Results (Including Syrian Population) - *(Continued)*

Province	Letter Grade	ASO Technological Development Index of Provinces	ASO Technological Development Index of Provinces	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour Attractive-ness (no.)
Çankırı	CC	0,29	20	62	26	23	10	25
Çanakkale	CC	0,29	21	33	37	22	31	4
Bilecik	CC	0,29	22	22	15	24	38	43
Kütahya	CC	0,28	23	52	14	29	35	15
Elazığ	CC	0,28	24	30	6	38	32	59
Rize	CC	0,28	25	38	25	27	27	19
Sivas	CC	0,28	26	16	18	42	24	44
Muğla	CC	0,28	27	36	52	14	75	1
Samsun	CC	0,28	28	23	30	19	29	36
Yalova	CC	0,27	29	37	28	40	15	30
Zonguldak	CC	0,27	30	51	47	16	30	16
Malatya	CC	0,25	31	32	33	18	45	38
Balıkesir	CC	0,25	32	43	48	20	46	12
Adana	CC	0,25	33	15	32	15	42	65
Kırklareli	CC	0,24	34	9	38	63	70	5
Erzurum	CC	0,24	35	35	21	53	28	42
Karaman	CC	0,24	36	70	31	44	14	32
Bartın	CC	0,23	37	58	39	36	21	31
Burdur	DD	0,22	38	76	23	55	26	20
Aydın	DD	0,21	39	55	42	25	48	33
Nevşehir	DD	0,21	40	56	41	58	20	26
Tokat	DD	0,21	41	46	45	57	13	57
Niğde	DD	0,20	42	45	17	56	34	60
Ardahan	DD	0,20	43	81	74	7	80	3
Adıyaman	DD	0,20	44	54	53	3	51	70
Kırıkkale	DD	0,20	45	41	27	47	64	37
Amasya	DD	0,20	46	73	70	6	60	45
Kastamonu	DD	0,20	47	63	54	51	40	8
Kars	DD	0,19	48	11	59	65	49	39
Uşak	DD	0,19	49	53	44	28	66	41
Aksaray	DD	0,19	50	71	73	9	55	55

Province	Letter Grade	ASO Technological Development Index of Provinces (score)	ASO Technological Development Index of Provinces (no.)	Sectoral Structure (no.)	Research and Innovation Capacity (no.)	Digital Infra-structure (no.)	Technology Outputs (no.)	Quality of Life and Labour
Artvin	DD	0,17	51	77	68	10	79	40
Mersin	DD	0,16	52	34	43	72	33	54
Gaziantep	DD	0,16	53	39	46	68	12	75
Afyonkarahisar	DD	0,16	54	68	56	35	59	50
Bayburt	DD	0,16	55	57	69	48	43	52
Çorum	DD	0,16	56	44	65	31	56	61
Yozgat	DD	0,15	57	69	50	39	73	46
Erzincan	DD	0,15	58	47	58	54	76	34
Sinop	DD	0,14	59	74	76	64	44	18
Kahramanmaraş	DD	0,14	60	40	49	52	36	71
Iğdır	DD	0,14	61	27	40	71	47	63
Ordu	DD	0,14	62	67	78	41	61	49
Tunceli	DD	0,13	63	80	67	74	18	35
Kırşehir	DD	0,12	64	78	62	46	65	53
Diyarbakır	FF	0,11	65	13	64	61	52	77
Ağrı	FF	0,11	66	25	79	49	67	68
Giresun	FF	0,10	67	79	60	60	74	47
Bingöl	FF	0,10	68	75	72	69	58	51
Van	FF	0,10	69	28	36	70	53	79
Batman	FF	0,10	70	18	55	73	57	73
Hatay	FF	0,09	71	65	57	59	63	67
Osmaniye	FF	0,07	72	72	61	62	54	74
Kilis	FF	0,06	73	48	66	67	77	72
Gümüşhane	FF	0,06	74	59	51	77	71	62
Bitlis	FF	0,04	75	50	71	76	78	64
Siirt	FF	0,04	76	64	63	75	68	69
Hakkari	FF	0,03	77	29	81	66	81	80
Muş	FF	0,02	78	61	75	79	69	66
Mardin	FF	0,00	79	66	80	78	50	76
Şanlıurfa	FF	0,00	80	49	35	81	62	81
Şırnak	FF	0,00	81	60	77	80	39	78

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