

Cluster Governance Analysis in Technical Textiles and Composite Materials Sector: A Regional Case Study

Mehmet KARAHAN

Bursa Uludag University, Türkiye, mkarahan@uludag.edu.tr

Ali ARI

Ostim Technical University, Türkiye, ali.ari@ostimteknik.edu.tr

Nevin KARAHAN

Bursa Uludag University, Türkiye, nkarahan@uludag.edu.tr

Abstract

Cluster governance is about identification and establishment of an organisational structure and organised efforts for managing relations, communication, flow and share of information and implementation of activities for achieving commonly shared vision of the cluster. Identification of the cluster organisational structure does not have any commonly agreed or accepted rules when cluster cases are reviewed. Additionally, variety of factors implies on success of organisational structures and their effectiveness. It is key to elaborate on maturity level of the cluster and level of operational capacity and resources. In most cases organisational structures or governance models of clusters linked with cluster management capacity and skills. In other words setting up a well-functioning cluster governance structure is highly related with well-functioning cluster coordination unit which is mostly known as cluster management team, responsible for a boards representing cluster profile as a whole. Identification of appropriate organisational structure for Bursa Technical Textile and Composite Materials Cluster has vital importance for the success of the cluster. The cluster has a variety of actors between large, medium and small scale companies, OEMs, strong universities, OIZs, stakeholders and public institutions where all actors have their own expectations, inputs, organisational rules. Therefore, establishment and launch of cluster is at formal bases important for continuation of cluster activities and implementation of the cluster strategy at collaborative and institutionalised way. Word "formal" does not mean establishment of formal body from the beginning of cluster development stages, however it is more about coordinating cluster activities for implementing the strategy has to be coordinated by an organisation and cluster coordination unit with full time team(s) work at daily basis to coordinate identified actions for the cluster.

Keywords

technical textiles, market analysis, high-value-added, Grubel-Lloyd Index, Bursa

1. Introduction

Cluster thinking has made notable progress in the economic policy agenda, academic circles, and the corporate world over the last three decades. Clusters are groups of businesses and organizations within the same industry, situated near each other, and connected by common features and differences. These clusters can work together to create synergies. In February 2015, a Google search for 'Cluster Competitiveness' returned 14,900,000 results [1-3]. The pages are mainly from prestigious institutions like the World Bank and organizations that support clustering, such as the US Cluster Mapping Project and the European Foundation of Cluster Excellence. Michael Porter is widely recognized for the significant impact he had on the popularity of clusters and their connection to competitiveness. Porter highlighted that the primary source of competitive advantage is situated within clusters. The World Economic Forum (WEF), an organization that frequently evaluates the economic conditions of leading countries worldwide, considers clusters to be a crucial element in national competitiveness. The Global Competitiveness Report (GCR) by WEF includes cluster development in a country as a factor under the pillar of 'business sophistication'. The business sophistication and innovation pillars are the most crucial elements of the WEF's Global Competitiveness Index. The level of interest in clusters can be gauged by the connections it has with various current events. Cluster development is considered a remedy for the

prevalent challenge of the "missing middle" issue encountered by small and medium enterprises (SMEs) in developing nations. Clusters have been recognized as drivers for fostering regional innovations and globalization in specific cases. The concept is intriguing, attracting the attention of governments as a policy instrument and corporations as a strategic decision. Governments in most countries are widely embracing the concept of promotion [4-6]. The literature thoroughly examines research on cluster development in advanced and emerging economies. Zeng credits China's significant growth in the last 40 years to industry clusters, offering a clear example of their impact. China is ranked second in cluster development, after Italy, in the World Economic Forum's Global Competitiveness Report (2014-15) among 144 nations. China's development trajectory showcases the effectiveness of Michael Porter's concept of clusters in driving the competitiveness of countries, regions, and industries. There is a scarcity of research on the competitiveness of clusters [5-7]. Most studies on clusters are mainly one-way.

The World Economic Forum (WEF) defines a nation's competitiveness as the combination of institutions, regulations, and factors that influence the country's level of productivity. Porter (2000) defined clusters as the essential foundation for enhanced productivity [8-9]. Clusters are subsets that belong to a nation. Clusters serve as a compact depiction of a country for evaluating competitiveness. This is due to their successful integration of local institutions, policies, and influences, which can then be extended to the national level. It is essential to measure the competitiveness of clusters to comprehend a nation's overall competitiveness.

We conducted regional and global market research on technical textiles and composite materials, analysing their added value. Based on our research:

The demand for high-value-added products like technological textiles is rising in global markets.

Many countries have revamped their production methods in the past ten years to prioritize the manufacturing of these goods to enhance their economic competitiveness internationally. Global exports of technical textiles amounted to approximately 118 billion dollars, showing a 3.38 percent growth compared to the previous year. Turkey's 2021 exports totalled \$2.413 billion, showing a 12.91% decrease from the previous year. The Grubel-Lloyd Index calculation for technical textile product groups in Turkey shows bilateral intra-industry trade, with only a few exceptions. The mean index value for all technical textile products was determined to be 0.7968. By 2028, Mobiltech, Indutech, and Packtech subcategories of technical textiles are projected to be the leading sectors in the commercial market [10-12].

The demand for high-value composite products, such as technical textiles, is rising in today's global markets. In the past ten years, numerous countries have transitioned their production techniques to focus on these goods in order to enhance their competitiveness in the global economy. Turkey's composite material exports grew by 19.48% in 2021 compared to the previous year, totalling 2.7 billion lira. The study determines that intra-industry trade in Turkey's composite material product categories is mainly bilateral, with a few minor exceptions, according to the Grubel-Lloyd Index calculation. The mean index value for composite materials was found to be 0.6890.

The authors examined the competitive factors in the technical textiles and composite industries [13]. The technical textiles and composite industry have a significant impact on the global economy due to factors such as production costs, technology, product quality, innovation, and sustainability, as indicated by this study. The technical textiles and composite industries' growth and success rely on their capacity to convert competitive attributes into value-added products. Value-added goods are differentiated from commodity goods by providing unique features, functionalities, and benefits. This enables businesses to increase prices and generate greater profits [14-19].

Initially, this study identified the primary participants, skills, and areas requiring development within the Bursa Technical Textile and Composite Materials Cluster ecosystem. It established the groundwork for the upcoming phases of cluster development in Bursa, particularly in creating the cluster strategy and implementation roadmap.

This study entailed implementing a cluster governance for the Bursa Technical Textile and Composite Materials Cluster. The study provides a strong basis for progressing the initial stage of cluster governance in Bursa, especially for developing the cluster strategy and implementation plan. Information is provided on regional factors that influence cluster development.

2. Methodology

Cluster governance is about identification and establishment of an organisational structure and organised efforts for managing relations, communication, flow and share of information and implementation of activities for achieving commonly shared vision of the cluster. Identification of the cluster organisational structure does not have any commonly agreed or accepted rules when cluster cases are reviewed. Additionally, variety of factors implies on success of organisational structures and their effectiveness. It is key to elaborate on maturity level of the cluster and level of operational capacity and resources.

In most cases organisational structures or governance models of clusters linked with cluster management capacity and skills. In other words, setting up a well-functioning cluster governance structure is highly related with well-functioning cluster coordination unit which is mostly known as cluster management team, responsible for a boards representing cluster profile as a whole.

Identification of appropriate organisational structure for Bursa Technical Textile and Composite Materials Cluster has vital importance for the success of the cluster. The cluster has a variety of actors between large, medium and small scale companies, OEMs, strong universities, OIZs, stakeholders and public institutions where all actors have their own expectations, inputs, organisational rules. Therefore, establishment and launch of cluster is at formal bases important for continuation of cluster activities and implementation of the cluster strategy at collaborative and institutionalised way. Word "formal" does not mean establishment of formal body from the beginning of cluster development stages, however it is more about coordinating cluster activities for implementing the strategy has to be coordinated by an organisation and cluster coordination unit with full time team(s) work at daily basis to coordinate identified actions for the cluster.

3. Cluster Governance

3.1. Legal Form of the Cluster

The issue of the legal structure of clusters has always been one of the controversial issues in cluster development environments. As of the times of this study is being written, Bursa Technical Textile and Composite Materials Cluster is at its initial stages in which relations among cluster actors is not matured and there is time for establishing trust-based relations. It is early for establishment of a legal structure in the form of an association or similar body for the cluster. At this stage establishment of such formal structure may even cause irreparable problems.

At this stage it is recommended to operationalize the cluster through launch of the Cluster Coordination Unit by assigning a cluster manager under the umbrella of a business support organisation, which can be BISO or BUTEKOM. Upon performance, collaborative projects and development of relations, establishment of a formal body may be considered after third year of the cluster development process.

3.2. Governance Structure of the Cluster

In cluster governance commonly observed and functioning governance structure includes elements of; advisory board, steering committee, cluster manager (cluster coordination unit) and formulation of working groups. Based on the current maturity level of the cluster a hybrid model is recommended where elements of "bottom-up" and "top-down" governance can be utilized. The final organisational structure should include an advisory board, a steering committee, cluster management and working groups - if working groups function well in the short-term period (Figure 1).

For the initial phase of the cluster; for the first year; establishment of an advisory board and cluster coordination unit through assignment of cluster manager is recommended. In addition to advisory board and cluster coordination unit, formulation of two working groups is recommended to test and update cluster strategy and actions, ensure alignment with concrete needs of the cluster companies at the level of two segments; technical textiles and composite materials.

3.2.1. Advisory board

Advisory board of the cluster will comprise members from key stakeholders and companies of the cluster which will be elaborating on cluster strategy and advice on collaborations, lead for regional

decisions and support executive board for implementing projects through an integrated and participatory approach. Members of the Advisory Board of BUTEXCOM Project have to comprise representatives of other clusters such as Basdec, Textile Cluster, Composite Materials Cluster. Advisory Board can also have members from external environment of the cluster, which can bring value to cluster development and specialisation. Members can be among from universities, clusters and public institutions, which have strategic importance for BUTEXCOMP Cluster. Establishment of the Advisory Board can be realised following the Cluster Strategy Roadmap Workshop with through a formal meeting held in ERA premises. It will be expected all members to sign a commonly agreed document on roles and responsibilities of advisory board and members.

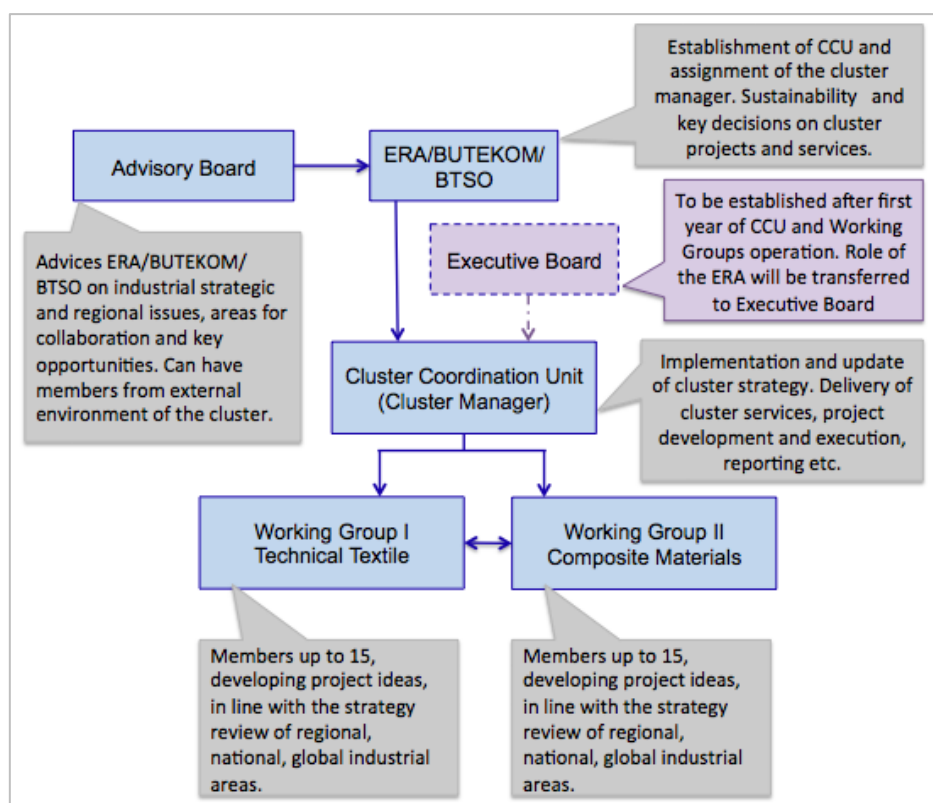


Fig. 1. Cluster Organisation Chart

3.2.2. Executive Board

Establishment of Executive Board of the cluster is recommended in the second year of the cluster based on the collaboration projects, involved members of the cluster, changes anticipated in cluster strategy. Since Executive Board is one of the most critical functioning bodies of a cluster, it is extremely important to have members who can work together and supervise cluster management team / cluster coordination unit towards vision of the cluster. Executive Board will be composed of 7 cluster members among from cluster companies at large and medium scale, representatives of universities and business support organisations. Until Executive Board is established the ERA/BUTEKOM/BTSO representatives will undertake related functions.

3.2.3. Establishment of Cluster Working Groups

Since BUTEXCOMP Cluster's sectorial scope comprises two different but complementary areas, in order to identify specific issues, project themes and accumulate industrial knowledge establishment of two working groups has been envisaged. It is recommended each working group; technical textiles and composite materials [14-19] will be formed of up to 15 members, coming once a month together to elaborate on identified cluster activities and future steps including development of applied research studies, identification/verification of international buyers, feedback for designed cluster activities and

possible new members of for the cluster and helping establishment of linkages and relations along with the cluster value chain. Meetings and interaction among two working groups will be coordinated by the cluster coordination unit, specifically by the cluster manager.

Working groups will also provide insights and project ideas for contributing AFFETTEK Platform and attributed roles for BTSO in areas related with cluster strategic priorities.

3.2.4. Cluster Coordination Unit - CCU and Cluster Management Team

Cluster Coordination Unit - CCU in other words Cluster Management Team plays vital role in operationalisation of the cluster. Main role of the CCU is to implement cluster strategy, to coordinate communication and information among different actors of the cluster, facilitate establishing fruitful environment for developing collaborative projects at internal and external environment of the cluster. As one of the primary reference platforms for clusters, in European Cluster Collaboration Platform and well-known cluster projects under COSME Programme puts a lot of emphasis on cluster management. Studies prove that along with strong and visionary cluster strategies, success of clusters is based on presence of dedicated cluster coordination units and their staff. At this point role of cluster manager is key for implementation of cluster activities mostly in the form of cluster services.

As Cluster Coordination Unit is a service unit for the member-companies of a cluster, offering support for a specified range of activities beyond national borders, also with the help of international networks. Typical cluster goals and services commonly seen in clusters comprise; promoting innovation, joint marketing and export promotion, building international alliances, joint procurement or sourcing, providing and/or directing business development services for cluster member companies, lobbying, developing projects etc. In line with the cluster strategy, identified cluster services can be reviewed in the next heading of the document.

Cluster Manager: Based on the action plan, development of projects and planned actions BUTEXCOMP Cluster can establish a team of Cluster Coordination Unit with a Cluster Manager, Project Manager and Business Development Manager. In the first year of the cluster implementation, Cluster Manager at full time basis can fulfil expected actions from CCU. However, starting with the second year and based on the started projects, which have been planned within the cluster, action plan take place, assignment of Project Manager and Business Development Manager has to be considered by the ERA.

Project Manager: Cluster Coordination Unit can employ Project Manager in consideration with the planned activities and expected workload from planned activities and projects. Since cluster management bodies are generating projects at national and international level for cluster companies and the cluster, assignment of a project manager can be considered for the future steps. It is expected that the Project Managers have at least two years of project design, development and implementation experience.

Business Development Manager: Based on the performance of cluster service delivery and interest of cluster companies on cluster services, Business Development Manager can be employed for coordinating and providing mainly the cluster services directly related with companies. Trainings, individual project development for accompanies, mentoring and consultancy services of the cluster as well as development of expert's pool to deliver aforementioned services can be coordinated by the business development manager.

3.3. Cluster Services

Cluster strategy and action plan can be implemented through identified set of cluster services. The Cluster Coordination Unit in collaboration will mainly deliver cluster services with cluster stakeholders and key partners. It is known that cluster services are also means for cluster sustainability. Experiences reveals that in most cases cluster services are for free or participation fee based. Some of the below services are interlinked and complementary. Services can be delivered through development of projects at cluster and company level or can be directly provided by the cluster management teams or networks' resources. In line with the cluster strategy and the cluster action plan key cluster services are identified as:

- Information and Training Services
- Internationalisation – Export Development and Partnerships Services

- Network Development Services
- Innovation Services
- Marketing and Promotion Services
- Industrial Tests and Analysis
- Project Development Services

3.3.1. Information and Training Services

Information and trainings services of the cluster are:

- Generation and distribution of knowledge of cluster companies about industry, market information, trends, strategic developments and up to date information in relation with industry value chain. Service will be delivered through disseminating information, documents and publications gathered through different services in the cluster web site and / or circulating among cluster member companies.
- In collaboration with cluster stakeholders' delivery of theoretical, technical and practical information to achieve goals of the cluster for innovation, productivity and internationalisation. Trainings delivered as cluster service can be organised in relation with other group of services and projects developed.
- Development of projects with regional educational actors such as vocational schools, universities and where skills development is necessary for technical textile and composite materials manufacturing and commercialisation purposes.
- Seminars, trainings and skills development services for employees of cluster companies. This cluster service can be delivered through joint projects developed by the cluster and utilization of internal resources of the cluster stakeholders and members of the advisory board.

Some of the Identified Training Themes and Areas:

Below are the examples of training themes that can be delivered for cluster companies and their employees. Training themes and areas will be defined over the course of the cluster development phase and cluster working group meetings.

- Industry specific trainings on materials; use of reinforcement materials, renewable materials in technical textiles and composite manufacturing,
- How to manufacture lightweight thermoplastic composite materials, world cases and success stories,
- Innovation and commercialisation in technical textile and composite materials industry,
- IPR, Patent and Licence process and agreements for new ideas, projects and partnerships,
- Circular economy principles, sustainability and digitisation in technical textile and composite materials along with the industry value chain,
- Industrial accreditations and certification processes.

3.3.2. Innovation Services

Innovation service of the cluster is the key and most important service for achieving cluster vision and goals identified under each cluster action. Delivery of innovation service will be based on the approach of facilitating and promoting applied research and innovation capacity development in the cluster. Cluster through its services will help cluster companies from TRL1 to TRL 9 of their innovation stages (Figure 2).

Delivery of innovation service will be designed as a pack and delivered in a cascading method with BUTEKOM services and competences. For smooth delivery of innovation service there is need for capacity development of cluster team and related team members. However, development and delivery of this service is essential for the cluster.

Through this service; in the long term it is aimed to position cluster as the centre for applied R&D and innovation in technical textiles and composite materials.

Cluster will manage projects by assisting with contractual and intellectual property aspects and helping cluster companies to realise their innovation potential. Cluster will also provide access to sources of co-funding, on a regional, national and European level.

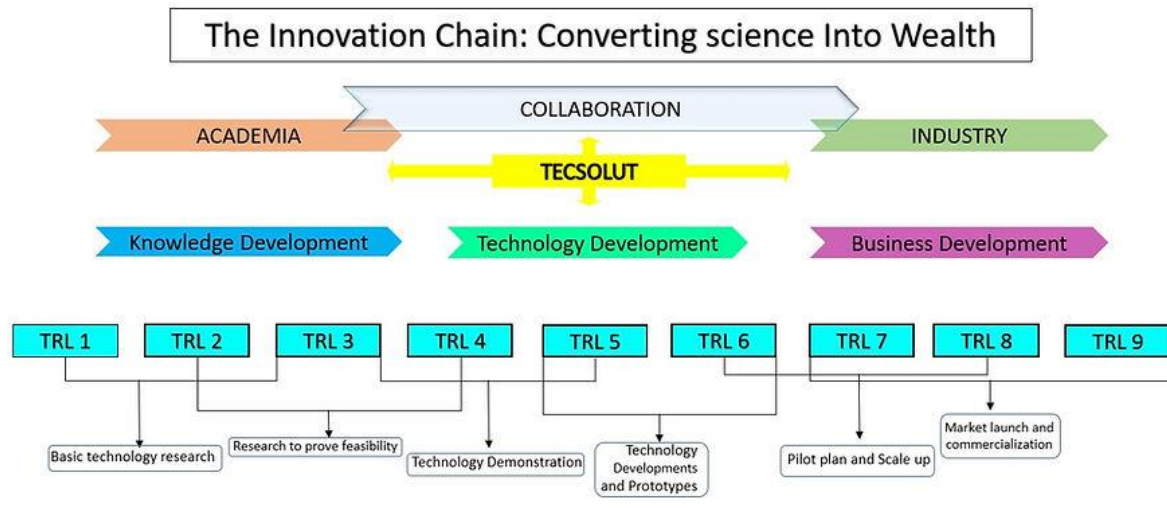


Fig. 2. Approach behind cluster innovation service [20]

3.3.3. Industrial Test and Analysis Services

Cluster services of industrial test and analysis will be provided through BUTEKOM services. Cluster will be promoting and dissemination BUTEKOM test and analysis services through its communication and project development capabilities.

3.3.4. Network Development Services

Cluster network development services will be delivered at regional, national and international level in line with the planned cluster action plan. Cluster Coordination Unit will undertake communication and networking events, visits and utilize communication and promotion tools to for establishment of long-term partnerships for cluster members. Network development services will constitute grounds for developing cluster project ideas and development of projects for sustainability of the cluster.

- Some of the key service areas;
- Networking efforts for increasing number of cluster members,
- Network development for developing partnership opportunities at regional, national and international level,
- Lobbying activities at national and international level,
- Continuation of supply chain programme which has been initiated by the BUTEXCOMP Project.

3.3.5. Internationalization Services

Internationalisation services of the cluster will be delivered to maximise commercialisation efforts of the cluster. Second aim of internationalisation services will be for developing opportunities for technology transfer. To this end cluster internationalisation services will be undertaken to implement internationalisation strategy of the cluster through finding, creating opportunities for cluster and the cluster companies to establish commercial and technological partnerships.

In order to achieve goals of internationalisation cluster coordination unit will identify clusters, research institutions, organisations and platform to establish linkages and pool of potential partners for developing joint project and activities.

In terms of export development scope, cluster coordination unit will develop studies and collaborations to access market information, buyers, information on value chain integration and buyers purchase criteria and develop B2B and matchmaking events under the projects cluster develop for exporting purposes. Through internationalisation services CCU will contribute cluster member companies to achieve their internationalisation purposes. CCU will also integrate with related EU platforms and networks such as ECCP and EEN.

3.3.6. Marketing and Promotion

Marketing and promotion services of the cluster will be delivered in the light of cluster promotion and branding strategy and purposes. CCU will implement cluster activities and services for improving national and international visibility and recognition of the cluster and cluster member companies.

3.3.7. Project Development Services

Project development services will be delivered in the form of proposal development and application for national and international funds on behalf of the cluster. Project development services will be also provided for the cluster companies especially for contributing them to achieve their innovation and market development goals.

4. Conclusions

Discussions and recommendations were moderated in three main headings:

Cluster governance typically consists of an advisory board, steering committee, cluster manager (cluster coordination unit), and the establishment of working groups. A hybrid model combining "bottom-up" and "top-down" governance is recommended based on the current maturity level of the cluster.

The Cluster Coordination Unit will primarily provide cluster services in cooperation with cluster stakeholders and key partners. Cluster services are recognized as a method to ensure cluster sustainability.

The innovation service provided by the cluster is crucial for achieving the vision and goals outlined in each cluster action. The delivery of innovative services will focus on facilitating and promoting applied research and developing innovation capacity within the cluster.

BUTEKOM will offer cluster services for industrial testing and analysis. Cluster will be promoting and disseminating BUTEKOM test and analysis services using its communication and project development capabilities.

Cluster network development services will be provided at regional, national, and international levels according to the scheduled cluster action plan. The Cluster Coordination Unit will organize communication and networking events, visits, and use various communication and promotion tools to establish long-term partnerships for cluster members. Cluster network development services will be provided at regional, national, and international levels according to the scheduled cluster action plan. The internationalization cluster coordination unit will identify clusters, research institutions, organizations, and platforms to establish connections and potential partners for developing joint projects and activities.

The cluster's marketing and promotion services will be provided according to the cluster's promotion and branding strategy and objectives. Project development services will involve creating proposals and applying for funding from national and international sources for the cluster.

Acknowledgements

This work was based on the "Technical Assistance for the "Composite Material and Technical Textile Prototype Production and Application Center" project, Reference number EuropeAid/140069/IH/SER/TR, Contract Number TR14C1.1.09-04/001/Service, which was co-funded by the European Union and the Republic of Türkiye. The authors would like to express appreciation to ITC Trade Map, TÜRKİYE Statistical Institute (TURKSTAT), and Istanbul Textile and Apparel Exporters' Associations (ITKIB) for making market related data accessible and sharing GTIP codes and classifications.

References

1. Babkin A.V., Kudryavtseva T.J., Utkina S.A. (2013): *Identification and Analysis of Industrial Cluster Structure*. World Applied Sciences Journal, ISSN 1818-4952, Vol. 28(10), pp. 1408-1413, DOI: 10.5829/idosi.wasj.2013.28.10.13923
2. Porter M.E. (1998): *Clusters and the New Economics of Competition*. Harvard Business Review, ISSN 0017-8012, Vol. 76, pp. 77-90
3. Rosenfeld S.A. (1997): *Bringing Business Clusters into the Mainstream of Economic Development*. European Planning Studies, eISSN 1469-5944, Vol. 5, is. 1, pp. 3-23, <https://doi.org/10.1080/09654319708720381>
4. Porter M.E. (1990): *The Competitive Advantage of Nations*. Free Press, ISBN 978-0029253618

5. Herliana S. (2015): *Regional Innovation Cluster for Small and Medium Enterprises (SME): A Triple Helix Concept*. Procedia - Social and Behavioral Sciences, ISSN 1877-0428, Vol. 169, pp. 151-160, <https://doi.org/10.1016/j.sbspro.2015.01.297>
6. Zeng D.Z. (2011): *How Do Special Economic Zones and Industrial Clusters Drive China's Rapid Development?* <https://doi.org/10.1596/1813-9450-5583>
7. Farinha L.M.D.C., Ferreira J.J.D.M., Gouveia J.J.B. (2014): *Innovation and Competitiveness: A High-Tech Cluster Approach*. The Romanian Review Precision Mechanics, Optics & Mechatronics, eISSN 2247-7063, Vol. 45, pp. 41-48, <https://api.semanticscholar.org/CorpusID:111411729>, https://www.researchgate.net/publication/267153595_Innovation_and_Competitiveness_A_High-Tech_Cluster_Approach
8. Bhawsar P., Chattopadhyay U. (2018): *Evaluation of Industry Cluster Competitiveness: A Quantitative Approach*. Benchmarking: An International Journal, ISSN 1463-5771, Vol. 25, pp. 2318-2343, doi:10.1108/BIJ-02-2017-0022
9. Porter M.E. (2000): *Location, Competition, and Economic Development: Local Clusters in a Global Economy*. Economic Development Quarterly, eISSN 1552-3543, Vol. 14, is. 1, pp. 15-34, <https://doi.org/10.1177/089124240001400105>
10. Bhawsar P., Chattopadhyay U. (2018): *Evaluation of Industry Cluster Competitiveness: A Quantitative Approach*. Benchmarking: An International Journal, ISSN: 1463-5771, Vol. 25, is. 7, pp. 2318-2343, <https://doi.org/10.1108/BIJ-02-2017-0022>
11. Karahan M.; Ahrari M., Karahan N. (2023): *Technical Textiles Market Research and Added Value Analysis: A Regio-Global Case Study*. RECENT, eISSN 2065-4529, Vol. 24, is. 71(3), pp. 162-180, <https://doi.org/10.31926/RECENT.2023.71.162>
12. Karahan M., Ahrari M., Karahan N. (2023): *Composite Materials Market Research and Export Potential Analysis: A Regio-Global Case Study*. RECENT, eISSN 2065-4529, Vol. 24, is. 70(2), pp. 113-121, <https://doi.org/10.31926/RECENT.2023.70.113>
13. Ahrari M., Karahan M., Karahan N. (2023): *Competitiveness Factors in Textiles and Composites Industry and Transformation into Value-Added Products*. RECENT, eISSN 2065-4529, Vol. 24, is. 70(2), pp. 132-141, <https://doi.org/10.31926/RECENT.2023.70.132>
14. Ari A., Karahan M., Ahmed H.A.M., Babiker O., Dehşet R.M.A. (2023): *A Review of Cellulosic Natural Fibers' Properties and Their Suitability as Reinforcing Materials for Composite Panels and Applications*. AATCC Journal of Research, eISSN 2330-5517, Vol. 10, is. 3, pp. 163-183, <https://doi.org/10.1177/24723444221147365>
15. Ari A., Karahan M., Kopar M., Ahrari M., Khan R.M.W.U., Hussain M. (2023): *Comparative analysis of natural fibres characteristics as composite reinforcement*. Industria Textila, ISSN 1222-5347, Vol. 74, is. 4, pp. 403-411, doi.org/10.35530/IT.074.04.2022110
16. Ari A., Bayram A., Karahan M., Arslan O. (2023): *Comparative evaluation of mechanical properties of short aramid fiber on thermoplastic polymers*. Materials Science-Poland, eISSN 2083-134X, Vol. 41, is. 1, pp. 161-176, <https://doi.org/10.2478/msp-2023-0012>
17. Ari A., Karahan M., Karahan N. (2024): *Competency Mapping of Textile and Composite Industries: A Regional-Global Case Study*. RECENT, eISSN 2065-4529, Vol. 25, is. 72(1), pp. 20-39, <https://doi.org/10.31926/RECENT.2024.72.020>
18. Karahan M., Ari A., Karahan N. (2024): *Examination of R&D Capacity in the Technical Textile Sector: A Regio-Global Case Study*. RECENT, eISSN 2065-4529, Vol. 25, is. 72(1), pp. 4-19, <https://doi.org/10.31926/RECENT.2024.72.004>
19. Karahan M., Karahan N., Ari A. (2024): *Market Trends of Türkiye Textile and Composite Industries: A Regional-Global Case Study*. RECENT, eISSN 2065-4529, Vol. 25, is. 72(1), pp. 40-54, <https://doi.org/10.31926/RECENT.2024.72.040>
20. <https://www.tecsol.com/>