

Technical Textiles Market Research and Added Value Analysis: A Regio-Global Case Study

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Abstract

High-value-added products such as technical textiles are increasingly in demand in global markets. In the last decade, many countries have transformed their production processes towards producing these products, aiming to become more competitive in the international arena in terms of economy. This study aims to reveal the current situation of the textile industry and its transition to higher value-added technical textiles in Türkiye, particularly in Bursa, as one of the textile hubs. Current global trade volumes of products, import-export data, and Türkiye's position in this sector are analyzed. Additionally, technology and market trends for technical textile products are discussed. The number of global exports in technical textiles increased to approximately 118 billion dollars, increasing by 3.38% compared to the previous year. Türkiye's exports in 2021 were realized as 2,413 billion dollars, a decrease of -12.91% compared to the previous year. Calculating the Grubel-Lloyd Index in Türkiye's technical textile product groups revealed that the intra-industry trade is two-way, except for a few product groups. The average index value for all technical textile products was calculated as 0.7968. Technical textiles are classified into 12 subcategories according to their application areas. It is anticipated that by 2028, the most significant trade items will be in the Mobiltech, Indutech, and Packtech subcategories of technical textiles.

Keywords

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

1. Introduction

The demand for technical textile products, which stand out with their specific physical and functional properties and performances in global markets, is increasing day by day [1–10], unlike products such as ready-made clothing, upholstery, and home textiles conventionally produced by the textile industry. The market continues to expand as technical textiles are used by an increasing number of end users in various industries such as agriculture, construction, healthcare, transportation, packaging, sports, environmental protection, and protective clothing [11]. Türkiye maintains its place among all the countries in the world, especially in the production and export of technical textiles and its export rates are increasing gradually [12–14]. It is predicted that the competitive power in global markets will increase as new technologies are developed in the production processes of technical textiles, which have higher added value compared to conventional textile products [15], and the increase in qualified personnel accompanies this. It is thought that the expectations that the fluctuations created by the COVID-19 pandemic in demand and supply will end as of the current year and the nature of the transformations brought about by the international agreements that are closely related to Türkiye, such as the European Green Deal [16], will become clearer and increase the search for new markets by the manufacturers. Market research and export potential analysis, tries to produce answers to a few key issues from a specific methodological framework. This methodology that is called as "Data Triangulation" [17] is based on bringing three different approaches. Of these, the 'Top-Down Approach' [18] requires first of all to present the market share and market volume of technical textiles [19–21] in Türkiye and in the world, with current numbers and ratios. Thus, a general view of the market will be obtained and a clearer image of the sector will be created for exporters. The 'Bottom-Up Approach', on

the other hand, includes identifying Türkiye's potential export markets for each of them by considering high value-added technical textiles one by one with their six-digit codes (GTIP) defined in the Harmonized System. The backbone of this study is to reveal these markets. The Qualitative Data approach, on the other hand, refers to the blending of insights obtained from 50 deep interviews conducted with key factors such as manufacturers, unit directors, development agencies and academicians operating in the sector for market research, with the numerical data revealed in other approaches. In the deep interviews, various questions were asked to the key actors interviewed, such as how they perceive the future of the technical textiles industry, which technological trends they think will come to the fore, what the manufacturers in Türkiye should aim for in competition with other competitors in the world, and the answers received were interpreted together with numerical data. In addition, the market trends that will reveal which product groups the market is heading towards in technical textiles are emphasized by making use of the analysis reports of international organizations. At the same time, a SWOT analysis [22] has been made in which the strong-weak sides of Türkiye in these areas and the threats and opportunities will be discussed. In accordance with our methodology, this analysis is also evaluated together with the insights obtained from the qualitative data. Finally, the Grubel-Lloyd index [23, 24], which measures Türkiye's intra-industry trade balance in technical textiles, was calculated for 6-digit sub-product groups one by one. As will be explained in detail below, this index, which takes a value between 0 and 1, reveals whether the country is engaged in one-way or two-way trade in product groups. To put it more clearly, when the index value approaches 0 in a product group, it means that trade is carried out unidirectionally in terms of imports or exports, and close to 1 means that both the import and export of the same product are carried out in nearly equal amounts. As the index value approaches 1, it is concluded that the trade in the product group in question is healthier in terms of economic theory. In the study, the Grubel-Lloyd index was also used to determine potential export markets. In technical textiles product groups, the countries with more imports than exports (that is, the index value is close to 0 in terms of imports) were determined and considered as an analysis criterion in determining the countries with export potential. This study aims to present a roadmap for technical textiles manufacturers in their search for new markets and to show where the potential markets can be. In which of the technical textiles groups Türkiye has more export potential and to which countries exports can be realized at a higher level in these potential areas are discussed. Thus, this study also has a content that reveals Türkiye's own potential in technical textiles. At the same time, it is aimed to help in identifying new product categories by determining technology and market trends in these product groups.

2. Methodology

A comprehensive methodology for performing market analysis of technical textiles in Türkiye and globally, using data collection, GTIP codes, per kg prices, import-export balancing, and Grubel-Lloyd index had been carried out. Data was collected from various sources, such as industry reports, market research reports, trade publications, government agencies, and company websites. The collected data included information on the technical textiles market, such as production, consumption, trade volumes, and pricing. GTIP (Harmonized System) codes were used to classify technical textile products into specific categories. The codes were used to identify the specific products being traded, their origin, and destination. Prices/kg for technical textiles products were collected from various sources, including customs data, industry reports, and trade publications. The prices were used to analyze the competitiveness of technical textiles products in the global market. The import and export data for technical textile products were collected from various sources, including customs data and trade publications. The data were used to determine the trade balance in technical textiles products between Türkiye and the rest of the world. The Grubel-Lloyd index was used to measure the intra-industry trade in technical textile products between Türkiye and the rest of the world. The index was used to determine the degree of specialization and competitiveness of Türkiye in the global technical textiles market.

Using these methods, a comprehensive market analysis of technical textiles in Türkiye and globally was conducted. The collected data was used to identify the major players, market size, and trends in the technical textiles market. The GTIP codes were used to classify technical textiles products, and per kg

prices were used to evaluate the competitiveness of these products. The import-export balancing and Grubel-Lloyd index were used to analyze the balance of trade and the degree of competitiveness of Türkiye in the global technical textiles market.

3. Global Technical Textile Export

The increase in global export rates in the past five years is the most unambiguous indication of the increasing demand for technical textiles worldwide. As can be seen in Figure 1, the global export rate in technical textiles has increased every year except for 2019. The number of exports, 103 billion dollars in 2017, increased by 3.38% compared to the previous year, with 117 billion dollars in 2021. Although it seems meaningful at first to explain the increase in demand for certain product groups with the COVID-19 pandemic, the fact that technical textiles are being applied more in our daily lives, from clothing to health, should not be ignored.

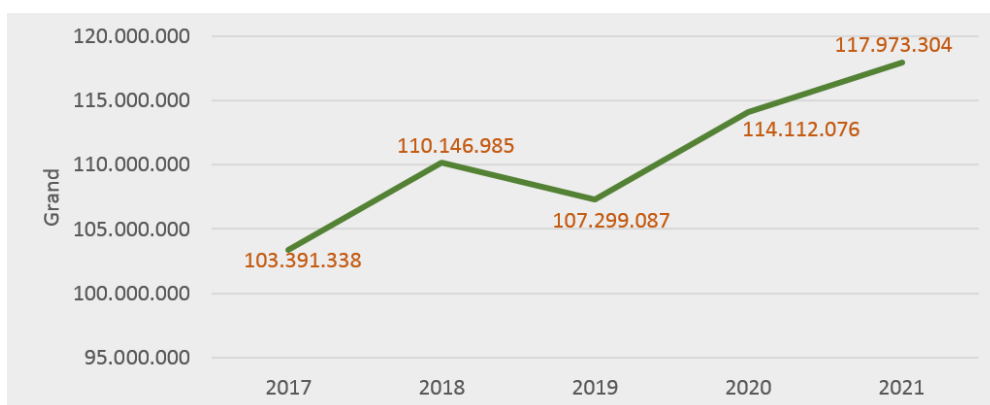


Fig. 1. Global technical textile export quantity encompassing 2017-2021 [25]

When we look at the export rates of the countries (Figure 2) [25], we can see that China has the highest trade volume in technical textile products. Although China's exports decreased in 2021, it was higher than the total exports of the five countries that followed it in both 2020 and 2021. While China's share in global technical textile exports was 32.8% in 2020, its share in 2021 decreased to 26.7%. This country is followed by Germany, USA, Italy and Vietnam in export rates, respectively. While there is a decrease in the rate of change in technical textile exports on a country basis between 2020-2021 in China, Mexico and Türkiye, an increase is observed in other countries. Türkiye's total exports in technical textiles decreased to 2,413,500,682 dollars.

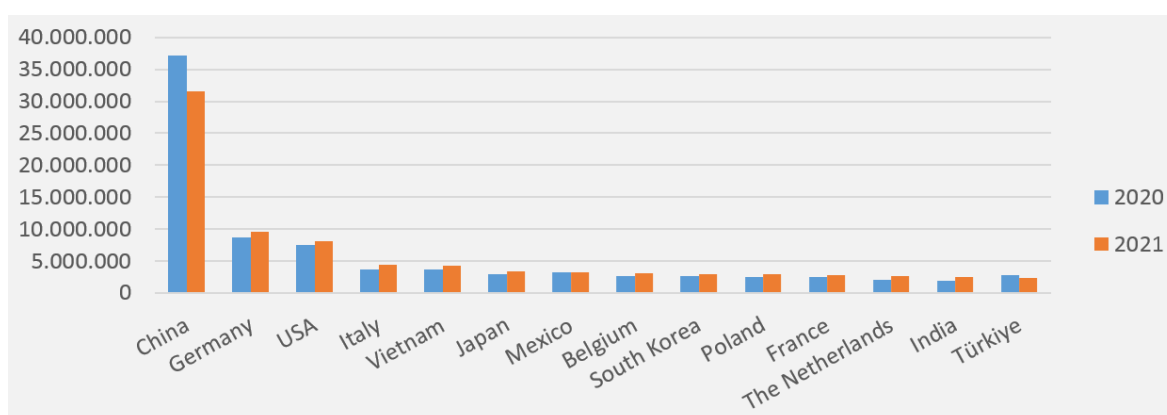


Fig. 2. Top 14 technical textile exporter countries (2020-2021) [25]

At this point, comparing the exports of China and Germany, which share the first two places in global technical textile exports, reveals noteworthy results. In the Table 1 below, it can be seen how many products and product groups both countries exported in 2020 and 2021 based on GTIP codes.

Table 1. Comparing the exports of China and Germany [25]

China	2020	2021	Product Group	Germany	2020	2021
540211	20,872	41,169	High Tenacity Yarn	540211	No Info	No Info
540219	254,632	369,754		540219	No Info	No Info
540220	553,921	735,611		540220	101,524	115,167
540310	1,055	2,232		540310	No Info	No Info
540600	73,215	87,642		540600	1,317	1,486
540710	66,946	72,424	Woven Fabric from High Tenacity Yarn	540710	139,790	125,680
540810	1,502	2,001		540810	14	67
5601	330,448	357,815	Wadding and Felts	5601	94,095	105,894
5602	183,075	211,617		5602	212,588	246,098
5603	5,048,778	4,161,142	Nonwoven	5603	2,087,774	2,342,202
5604	433,797	377,225	Rubber Yarn and Ropes	5604	21,216	27,448
5605	86,346	84,925	Metalized Yarn and Fabric	5605	7,697	8,877
5809	1,876	2,436		5809	419	639
5607	843,656	953,325	String, Yarn, Ropes and Draw cords	5607	101,757	122,861
5609	304,281	377,546		5609	42,775	52,329
5608	781,757	889,390	Gill Nets and Other Nets	5608	76,754	81,358
5902	550,380	972,213	Cord Fabric	5902	32,030	47,751
5903	4,452,248	5,451,701	Impregnated, Smeared, Coated Fabric	5903	892,328	1,026,225
5904	40,588	23,876	Floor Coverings	5904	16,871	15,476
5906	164,390	199,193	Rubber Band and Fabric	5906	334,770	355,651
5908	4,625	6,337	Roving, Hose, Carrier Column and Other Technical Goods	5908	15,674	20,817
5909	118,308	124,161		5909	48,084	55,225
5910	85,126	108,393		5910	114,379	128,865
5911	644,084	725,112		5911	818,950	939,913
6113	226,332	292,739	Ready-made Clothing from Technical Textile Materials	6113	56,309	69,940
6210	13,327,204	4,483,367		6210	579,917	578,718
630532	411,888	435,269	Bags and Sacks	630532	66,968	83,115
630533	808,569	895,022		630533	16,301	21,266
6306	2,938,697	4,004,143	Wagon, Barge Cover, Sail and Camping Equipment	6306	307,496	397,286
630710	1,269,525	1,241,951	Cleaning Cloths	630710	176,563	194,627
630720	205,237	245,367	Lifeguard Vests and Belts	630720	9,216	10,304
7019	2,192,167	2,842,061	Glass Fiber, Glass Fiber Products and Other Products	7019	883,859	1,014,698
870821	72,758	92,752	Seatbelts	870821	366,249	385,608
870895	717,012	701,987	Airbags	870895	991,539	1,032,888
8804	4,444	5,490	Parachutes	8804	14,617	22,839
	37,219,739	31,577,388			8,629,840	9,631,318

When the Table 2 is carefully examined, three product groups emerge as the locomotive of China's exports: 5603 (Non-Woven Fabrics), 5903 (Impregnated, Coated, Coated Fabrics) and 6210 (Ready-to-Wear from Technical Textile Material). Similar to Türkiye's experience, while China achieved very high export rates in the 6210 group in 2020, when the COVID-19 pandemic was the most intense, it experienced a sharp decline in the exports of the same product group in 2021. In the other two product groups, increases and decreases were at predictable levels. Germany, on the other hand, does not seem to have experienced similar sharp rises and falls in any product group. However, as seen in Figure 3, Germany achieved a growth rate of 11.60% in technical textiles in 2021.

This difference makes it possible to determine the character of the industries of the two countries. While China's technical textile industry adapts more easily to the changes and responds to the needs of the market more quickly, Germany does not make such rapid changes in its production processes. On the other hand, while China's said adaptive power has created sharp increases and decreases in its exports over the years, Germany has been increasing steadily.

Thus, the change compared to the previous year was -12.90%. With this ratio, Türkiye's share in total global technical textile exports is 2.04% (Figure 3) [25].

Table 2. The export amounts of Türkiye in the last four years in all product groups in technical textiles [28]

PRODUCT GROUP	GTIP	2018 Export (\$)	2019 Export (\$)	2020 Export (\$)	2021 Export (\$)
High Tenacity Yarn	540211	2,022,763	3,754,312	2,675,458	2,463,667
	540219	86,755,072	88,435,875	64,666,733	94,955,699
	540220	4,020,333	2,592,403	3,124,113	3,314,897
	540310	19,124	8,338	56,894	41,627
	540600	9,810,646	7,552,083	1,780,271	4,763,261
Woven Fabric from High Tenacity Yarn	540710	6,648,498	8,151,961	8,274,070	10,368,923
	540810	1,047,148	831,561	477,324	933,801
Wadding and Felts	5601	58,198,778	69,484,946	73,953,236	77,741,110
	5602	41,919,481	44,045,684	51,902,462	68,203,669
Nonwoven	5603	595,027,687	585,979,870	693,126,219	751,206,344
Rubber Yarn and Ropes	5604	12,880,216	15,175,346	18,814,071	19,452,545
Metalized Yarn and Fabric	5605	12,692,134	11,840,903	9,097,767	10,585,869
	5809	135,072	51,622	32,795	50,386
String, Yarn, Ropes and Draw cords	5607	26,961,125	30,190,750	43,667,806	57,356,016
	5609	4,586,201	4,813,964	5,875,639	9,935,485
Gill Nets and Other Nets	5608	11,579,869	13,418,448	15,494,092	17,472,650
Cord Fabric	5902	134,433,948	125,930,190	91,453,790	116,718,637
Impregnated, Smeared, Coated Fabric	5903	115,454,338	114,443,500	114,218,373	129,845,630
Floor Coverings	5904	1,008,516	863,183	412,395	407,247
Rubber Band and Fabric	5906	5,780,724	4,518,686	3,948,096	3,606,624
Roving, Hose, Carrier Column and Other Technical Goods	5908	262,171	88,357	58,011	106,420
	5909	947,118	972,140	806,674	1,060,003
	5910	2,706,782	2,471,916	2,351,953	10,585,088
	5911	32,954,787	28,935,648	28,887,978	33,381,423
Ready-made Clothing from Technical Textile Materials	6113	1,316,851	1,392,483	3,468,993	3,988,521
	6210	17,714,649	20,086,289	928,737,592	241,708,216
Bags and Sacks	630532	212,647,782	184,724,891	209,841,801	250,102,127
	630533	131,580,072	121,098,902	128,526,158	148,420,049
Wagon, Barge Cover, Sail and Camping Equipment	6306	42,661,612	50,000,771	48,900,705	54,373,091
Cleaning Cloths	630710	17,572,314	18,202,906	21,701,562	25,520,896
Lifeguard Vests and Belts	630720	1,701,816	1,462,228	1,107,784	1,897,303
Glass Fiber, Glass Fiber Products and Other Products	7019	93,898,075	86,660,687	93,212,899	149,457,954
Seatbelts	870821	79,566,071	81,347,368	89,060,231	96,739,987
Airbags	870895	11,989,987	10,191,625	11,492,126	16,400,785
Parachutes	8804	214,965	663,058	110,685	334,732
		1,778,716,725	1,740,382,894	2,771,316,756	2,413,500,682

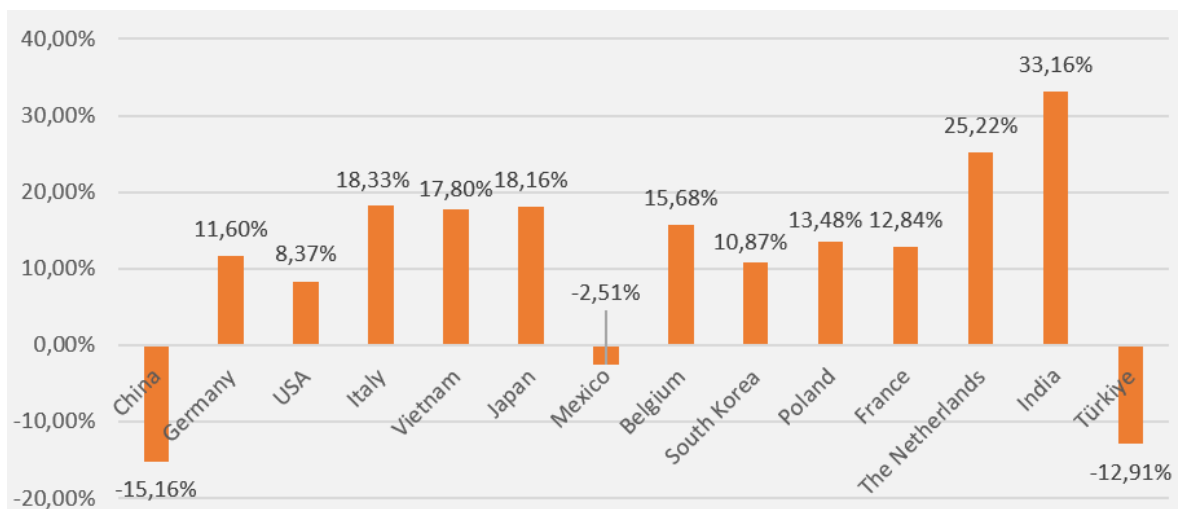


Fig. 3. Top 14 exporter countries change range in technical textile exports between 2020-2021 [25]

The second element that draws attention in this comparison is the product groups, which are the carriers of Germany's technical textile exports. Germany exports more products with prices per kilogram, means higher added value products than other groups of products i.e., Parachutes (8804), Airbags (870895), Seat Belts (870821) and Wick, Hose, Support Column and Other Technical Items (5911), compared to China. China, on the other hand, carries out higher volume production and exports in products with relatively lower added value. It would not be wrong to state that Germany ranks second in global technical textile exports thanks to this character of the technical textile industry. This determination presents important future data for Türkiye's technical textile industry.

It will be helpful to discuss the market shares and volumes of technical textiles in the global market in 2020 and provide forecast of 2028, according to fiber types. As can be seen in Figure 4 and Figure 5 [26], it is predicted that the market shares of both natural and synthetic fibers will almost double by 2028. We can see that synthetic fibers are preferred more than natural fibers in terms of market share and volume.

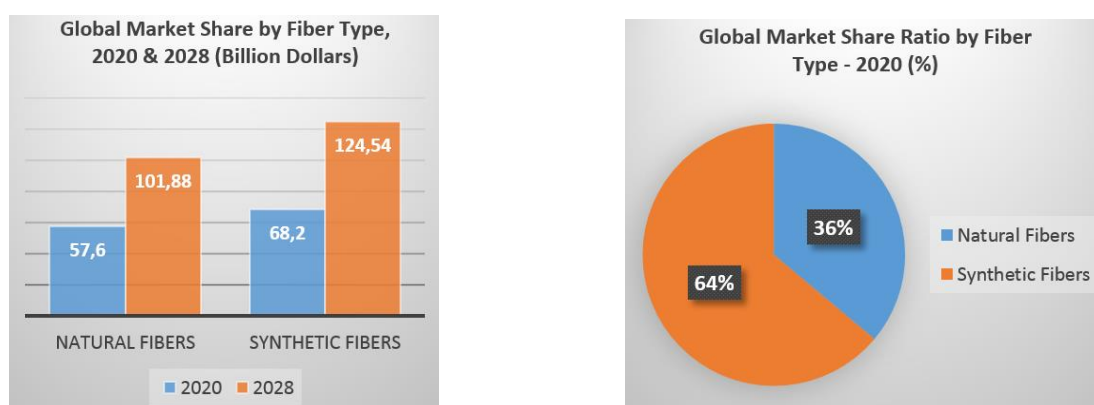


Fig. 4. Global market share ratio by fiber type in 2020 and 2020-2028 forecast [26]

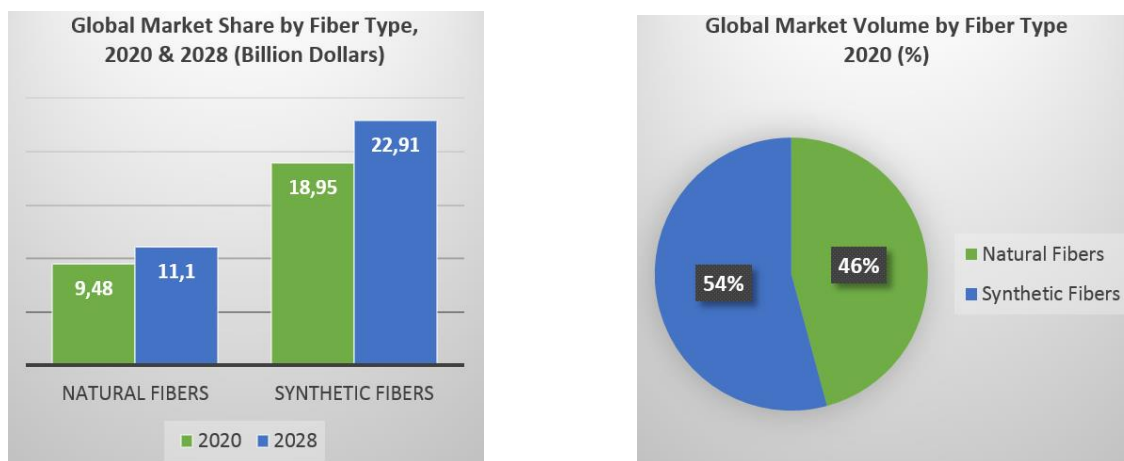


Fig. 5. Global market volume by fiber type in 2020 and 2020-2028 forecast [26]

4. Technical Textile Export and Import Amounts of Türkiye

In technical textiles, it can be said that Türkiye's import and export volumes in the last four years have followed a fluctuating trend. Although we observe very close rates in 2018 and 2019, there has been a huge increase in exports, especially in 2020, due to the increased demand for certain product groups due to the rise of the COVID-19 pandemic. The export increase of more than 4000% in the ready-to-wear product group from Technical Textile Material and more specifically in the group that includes the 6210 GTIP code 'Non-Knitted or Non-Crochet Clothing and Accessories', that is, medical masks, has led to an increase in the total export rate of all technical textiles. With this increase, Türkiye has risen to the eighth place among all countries in the export of technical textiles in 2020. However, when we came

to 2021, this increase showed a slight decrease in parallel with the fall in demand for the same product groups. Therefore, in 2021, Türkiye fell from 8th to 14th in global technical textile exports. Despite the decrease experienced in exports in 2021, the increasing trend seen over the years shows us that Türkiye can rapidly adapt, react, and increase its production capacity when it focuses on technical textile production, and in parallel, find wider markets in foreign trade (Figure 6) [27].

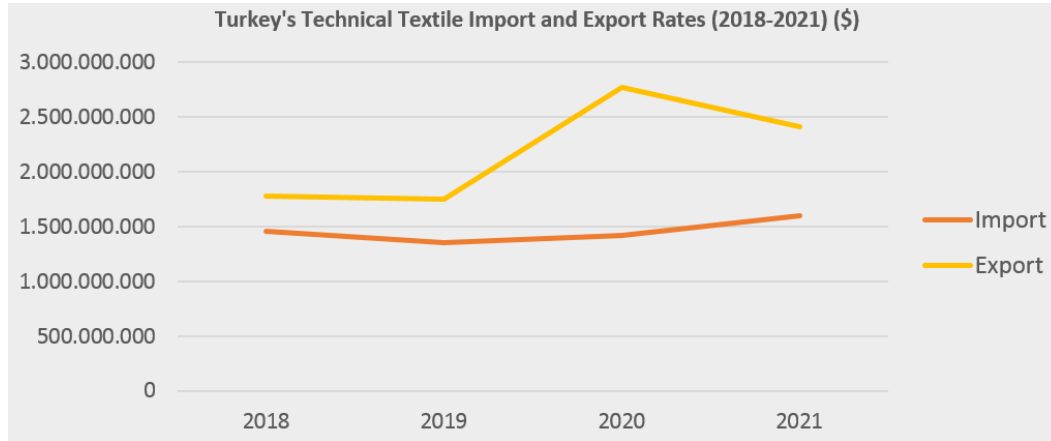


Fig. 6. Import and export rates of Türkiye’s technical textile [27]

In the upcoming three tables (Tables 3, 4, and 5), the export and import amounts of Türkiye in all product groups in technical textiles (35 GTIP codes and 22 product classes in total) in the last four years, respectively, and the trade balance of 2021 for each GTIP and product group are listed [28].

Table 3. The import amounts of Türkiye in the last four years in all product groups in technical textiles [28]

PRODUCT GROUP	GTIP	2018 Import (\$)	2019 Import (\$)	2020 Import (\$)	2021 Import (\$)
High Tenacity Yarn	540211	25,481,102	32,702,526	32,725,921	35,271,215
	540219	12,021,549	13,844,458	16,906,725	25,151,058
	540220	67,595,811	59,604,172	47,834,167	76,974,970
	540310	1,672,715	420,322	741,348	1,338,663
	540600	43,264	172,849	125,279	59,106
Woven Fabric from High Tenacity Yarn	540710	7,694,350	7,114,186	5,055,150	6,915,822
	540810	78,218	93,660	159,907	102,493
Wadding and Felts	5601	60,947,582	53,631,413	45,908,125	43,333,727
	5602	23,073,969	24,911,303	27,826,214	31,170,343
Nonwoven	5603	206,406,701	193,241,115	266,003,006	217,715,360
Rubber Yarn and Ropes	5604	4,555,325	4,469,160	5,681,450	6,007,313
Metalized Yarn and Fabric	5605	7,251,542	8,668,413	6,256,398	5,302,257
	5809	169,377	211,809	53,075	22,449
String, Yarn, Ropes and Draw cords	5607	17,544,372	19,072,491	23,042,982	28,181,359
	5609	4,625,338	3,282,826	4,708,314	5,646,671
Gill Nets and Other Nets	5608	7,963,208	7,236,949	7,271,995	9,264,611
Cord Fabric	5902	53,273,109	49,165,828	41,850,775	60,997,935
Impregnated, Smearred, Coated Fabric	5903	241,913,464	228,000,180	209,016,531	238,151,346
Floor Coverings	5904	1,338,474	669,411	672,553	633,737
Rubber Band and Fabric	5906	28,802,160	25,666,111	28,805,497	35,935,424
Roving, Hose, Carrier Column and Other Technical Goods	5908	47,045	44,408	51,939	97,782
	5909	2,010,634	1,572,235	1,120,084	1,656,210
	5910	11,772,890	13,281,740	13,936,736	15,602,949
	5911	60,452,373	58,632,057	65,117,579	76,026,268
Ready-made Clothing from Technical Textile Materials	6113	5,156,839	5,051,844	6,744,021	5,750,536
	6210	40,614,008	29,218,864	41,544,509	43,820,371
Bags and Sacks	630532	2,949,165	2,285,872	1,344,127	2,328,113
	630533	2,173,163	1,934,135	2,460,132	2,998,542

Wagon, Barge Cover, Sail and Camping Equipment	6306	10,999,702	13,411,024	35,901,137	34,569,088
Cleaning Cloths	630710	23,487,678	17,369,272	25,390,342	21,057,031
Lifeguard Vests and Belts	630720	2,706,174	3,528,793	2,149,460	2,496,032
Glass Fiber, Glass Fiber Products and Other Products	7019	259,946,007	242,658,512	256,514,924	368,260,877
Seatbelts	870821	61,705,195	52,206,105	45,981,320	50,362,546
Airbags	870895	201,102,458	180,067,658	147,962,237	144,047,683
Parachutes	8804	1,952,993	635,220	2,090,807	1,023,065
		1,459,527,954	1,354,076,921	1,418,954,766	1,598,272,952

Table 4. The trade balance of 2021 for each GTIP and product group [28]

PRODUCT GROUP	GTIP	2021 Trade Balance (\$)	Product Groups Trade Balance (2021)
High Tenacity Yarn	540211	-32,807,548	-33,255,861
	540219	69,804,641	
	540220	-73,660,073	
	540310	-1,297,036	
	540600	4,704,155	
Woven Fabric from High Tenacity Yarn	540710	3,453,101	4,284,409
	540810	831,308	
Wadding and Felts	5601	34,407,383	71,440,709
	5602	37,033,326	
Nonwoven	5603	533,490,984	
Rubber Yarn and Ropes	5604	13,445,232	
Metalized Yarn and Fabric	5605	5,283,612	5,311,549
	5809	27,937	
String, Yarn, Ropes and Draw cords	5607	29,174,657	33,463,471
	5609	4,288,814	
Gill Nets and Other Nets	5608	8,208,039	
Cord Fabric	5902	55,720,702	
Impregnated, Smeared, Coated Fabric	5903	-108,305,716	
Floor Coverings	5904	-226,490	
Rubber Band and Fabric	5906	-32,328,800	
Roving, Hose, Carrier Column and Other Technical Goods	5908	8,638	-47,662,706
	5909	-596,207	
	5910	-5,017,861	
	5911	-42,644,845	
Ready-made Clothing from Technical Textile Materials	6113	-1,762,015	196,125,830
	6210	197,887,845	
Bags and Sacks	630532	247,774,014	393,195,521
	630533	145,421,507	
Wagon, Barge Cover, Sail and Camping Equipment	6306	19,804,003	
Cleaning Cloths	630710	4,463,865	
Lifeguard Vests and Belts	630720	-598,729	
Glass Fiber, Glass Fiber Products and Other Products	7019	-218,802,923	
Seatbelts	870821	46,377,441	
Airbags	870895	-127,646,898	
Parachutes	8804	-688,333	
		815,227,730	

Table 5. Product-based increase and decrease in the import and export rates of technical textiles in the last four years [27]

	Import GTIP	Export GTIP
Sharp Increase	6306	5906, 5910, 6210, 7019
Regular Increase	540211, 540219, 5602, 5604, 5607, 5910	5601, 5602, 5603, 5604, 5607, 5609, 5608, 630710, 870821
Regular Decrease	5601, 5904, 870895	5906, 5904
Sharp Decrease	540310, 5809, 8804	540600, 6210

We can try to interpret the numbers in these three tables showing the import and export volumes of Türkiye in the last four years. Initially, we can see that Türkiye has an export surplus of 815 million dollars in technical textiles in 2021. We can read from the table that the locomotive product groups that ensure exports are more than imports are 5603 (Non-Woven Fabrics), 630532-630533 (Bags and Sacks), and 6210 (ready-to-wear from Technical Textile Materials). On the other hand, it turns out that imports are higher in certain product groups. For example, it can be seen that the import coverage ratio of exports is low in product groups such as 7019 (Glass Fiber Fabric), 870895 (Air Cushions), and 5903 (Impregnated, Coated, Coated Fabrics). The critical point here is the fact that these product groups with higher imports are products with higher added value than others. Therefore, the increase in production and exports in these groups, and the decrease in imports in parallel, will simultaneously increase export surplus exponentially.

Examining the product-based increase and decrease in the import and export rates of technical textiles in the last four years may also provide important clues. In Table 6, we can see which product group followed which trend. Most of the product groups show increases and decreases in different years, as can be expected. In this sense, they do not follow a clear line in terms of increase or decrease. However, while regular increases or decreases are observed in the imports or exports of some product groups, sharp increases and decreases can be observed in some products. We can briefly review some of them. For example, in the product group coded 6306, there was a 167% increase in imports in 2020 compared to the previous year, and this amount was realized in the same way in 2021. On the export side, there was an increase of approximately 5 times in 2021 in the product group coded 5910. In this four-year cross-section, the only product group that experienced both a sharp increase and a sharp decline in exports due to the pandemic was the 6210 ready-to-wear product group in Technical Textiles.

But the point to keep in mind here is that regular increases and decreases, rather than drastic increases or decreases, provide more valuable information. For instance, regular export increases can be seen as an indication that the market is expanding and the potential is high in terms of exports in the product group in question. Regular increases in imports will show that there is a greater need for that product group in the country and that there is a high demand for this product in the domestic market. Similarly, decreases in exports or imports can be read as an indication that the market in the product group in question has contracted. While there are nine product groups in which exports have increased regularly for four years, six product groups have increased in imports. A regular decrease is observed in two groups in exports and three in imports. Examination of these product groups by manufacturers provides an opportunity for them to reconsider their production processes and determine the direction of their trade. Reading the import and export figures in all these product groups together with the prices per kilogram given in Table 7 for each GTIP code will enable us to draw some conclusions. In addition, prices per kilogram based on product group can be examined [27].

There are some remarkable points in the table of prices per kilogram. Principally, except for a few product groups, the prices per kilogram in our imports are generally higher than our exports. In other words, the products we buy from abroad, although in the same product group, are more expensive than the ones we sell out. We think there may be several reasons for this. First, the fact that our biggest trade partner is EU member countries and the higher production costs in these countries cause us to give high figures in imports. Secondly, this table does not show the final product with a 12-digit GTIP code, even

though it is in the same GTIP. In this sense, there may be differences between imported end products and exported end products. Therefore, we can assume that the products we export are lower value-added products. As a final reason, the brand value of the products we import is higher than the ones we export. The higher the brand value, the higher the price per kilogram.

Table 6. Import and export price/kg and average price/kg based on GTIP numbers

Product Group	GTIP	Import price per kg (\$)	Export price per kg (\$)	Average price per kg based on product group (\$)	
				Import	Export
High Tenacity Yarn	540211	29.09	19.98	9.52	7.79
	540219	4.29	4.69		
	540220	1.90	3.29		
	540310	4.96	3.32		
	540600	7.38	7.67		
Woven Fabric from High Tenacity Yarn	540710	7.06	6.40	9.18	8.98
	540810	11.29	11.55		
Wadding and Felts	560121	3.37	4.21	6.81	3.50
	560122	8.88	5.41		
	560129	7.61	2.68		
	560130	4.81	1.59		
	560210	7.25	2.45		
	560221	14.55	9.17		
	560229	3.81	0.69		
	560290	4.19	1.81		
Nonwoven	560311	3.02	2.95	5.45	3.71
	560312	3.82	2.84		
	560313	5.11	3.26		
	560314	5.33	3.12		
	560391	5.14	4.02		
	560392	5.32	2.95		
	560393	6.87	7.33		
	560394	8.97	3.22		
Rubber Yarn and Ropes	560410	6.20	6.44	10.29	6.69
	560490	14.38	6.94		
Metalized Yarn and Fabric	560500	7.22	7.49	31.88	7.89
	580900	56.54	8.29		

In the import-export comparison, our product groups with higher export prices per kilogram can be listed as follows: Cord Cloth; Impregnated, Coated Fabrics; Floor Coverings; Bags and Sacks; Glass Fiber Fabric. However, it should be noted that these product groups are lower value-added products compared to others. In this sense, as can be seen once again, focusing on the production and export of high value-added products will enable manufacturers to reach higher profitability rates with similar production quantities and to establish the import-export balance of the country's economy.

5. Grubel-Lloyd Index of Türkiye's Technical Textile Product Groups

As mentioned earlier, the Grubel-Lloyd index is one of the most widely used methods to measure the intra-industry trade ratio. Intra-industry trade refers to the 'two-way' trade of similar products, i.e., both imports and exports. The fact that a product X is both imported and exported in similar amounts by a country indicates that the intra-industry trade rate for that product is high. It is observed that the intra-industry trade of developed and developing economies is generally high. In less developed economies, on the other hand, this ratio decreases due to the dependence on the import of certain products or

because a small number of products are produced in large quantities and become the main item of export. For instance, a country that does not produce any automobiles is foreign-dependent for this product and has to import only. Therefore, that country has a one-way trade in automobiles and in this sense, the intra-industry trade rate is low. Similarly, let's assume that the same country produces large quantities of wheat and this product, which is produced more than the country needs, is only exported. Again, we can say that this country's intra-industry trade in wheat is very low.

Table 7. Türkiye's technical textile products Grubel-Lloyd index based on GTIP numbers [27]

Product Group	GTIP	Grubel-Lloyd Index	Direction
High Tenacity Yarn	54 02 11	0.1306	Import Oriented
	54 02 19	0.4188	Export Oriented
	54 02 20	0.0826	Import Oriented
	54 03 10	0.0603	Import Oriented
	54 06 00	0.0245	Export Oriented
Woven Fabric from High Tenacity Yarn	54 07 10	0.8002	Export Oriented
	54 08 10	0.1978	Export Oriented
Wadding and Felts	56 01	0.7158	Export Oriented
	56 02	0.6273	Export Oriented
Nonwoven	56 03	0.4494	Export Oriented
Rubber Yarn and Ropes	56 04	0.4719	Export Oriented
Metalized Yarn and Fabric	56 05	0.6674	Export Oriented
	58 09	0.6164	Export Oriented
String, Yarn, Ropes and Drawcords	56 07	0.6589	Export Oriented
	56 09	0.7248	Export Oriented
Gill Nets and Other Nets	56 08	0.6930	Export Oriented
Cord Fabric	59 02	0.6865	Export Oriented
Impregnated, Smearred, Coated Fabric	59 03	0.7057	Import Oriented
Floor Coverings	59 04	0.7824	Import Oriented
Rubber Band and Fabric	59 06	0.1824	Import Oriented
	59 08	0.9577	Export Oriented
Roving, Hose, Carrier Column and Other Technical Goods	59 09	0.7805	Import Oriented
	59 10	0.8084	Import Oriented
	59 11	0.6102	Import Oriented
	61 13	0.8191	Import Oriented
Ready-made Clothing from Technical Textile Materials	62 10	0.3069	Export Oriented
	63 05 32	0.0184	Export Oriented
Bags and Sacks	63 05 33	0.0396	Export Oriented
	63 06	0.7773	Export Oriented
Wagon, Barge Cover, Sail and Camping Equipment			
Cleaning Cloths	63 07 10	0.9042	Export Oriented
Lifeguard Vests and Belts	63 07 20	0.8637	Import Oriented
Glass Fiber, Glass Fiber Products and Other Products	70 19	0.5774	Import Oriented
Seatbelts	87 08 21	0.6847	Export Oriented
Airbags	87 08 95	0.2044	Import Oriented
Parachutes	88 04	0.4931	Import Oriented
Türkiye Technical Textile Grubel-Lloyd Index		0.7968	Export Oriented

The Grubel-Lloyd (GL) index [23, 24] expressed by the following formula is used to show the ratio of this intra-industry trade. In the formula, X_i represents the import amount of product "i" and M_i represents the export amount of product "i".

$$GL_i = 1 - \frac{|X_i - M_i|}{(X_i + M_i)}$$

As a result of applying the formula, a value between 0 and 1 is obtained. If this value approaches 0, it means that the trade of the country in question in that product is one-way. In other words, that product is either only imported or only exported. If this value approaches 1, the trade in the same product is two-way; that means that both imports and exports of the product occur in similar quantities and intra-industry trade is high.

In Table 7, the Grubel-Lloyd index has been measured one by one in Türkiye's technical textile products on the basis of GTIP. In addition, the trade direction of each product is indicated on the far right of the table. For example, in the product group numbered 540211, Türkiye's intra-industry trade value was low, because this product has high imports and low exports. For this reason, it can be said that trade is one-way as "import-side".

When the table is examined, it can be seen that the Grubel-Lloyd index is calculated as 0.7968 for export in all technical textiles of Türkiye. Since this value is close to 1, it can be said that Türkiye's intra-industry trade in technical textile product groups is generally high. As stated earlier, this is the kind of result seen in developed or rapidly developing economies.

However, when the product groups are examined one by one, the situation in each product group differs. For example, the index value of product groups such as 540220 and 540310 on the import side are quite low. Our exports in these two product groups are extremely low. On the other hand, in the product groups 540600, 630532 and 630533, intra-industry trade was low this time in terms of exports. In other words, our imports are low and our exports are high in these three product groups. The first three product groups, where the index approaches 1 and therefore intra-industry trade is two-way, emerge as 5908, 630710 and 630720, respectively. In these product groups, our import and export quantities seem to be quite close to each other.

6. Potential Trade Markets for Technical Textiles

One of the most important concerns for manufacturers today is to expand their trade by finding new markets. Especially in the transition to the production of products with higher added value than conventional textiles, such as technical textiles, but with higher production costs, the first thing that comes to mind is the demand for these products and in which markets this demand is concentrated. Since it will be considered risky to change the production processes without getting clear answers to these questions, it is necessary to first reveal where the potential export markets are. In this part of our study, we tried to determine which countries these export markets are, with six-digit GTIP codes, for a total of 86 product groups. We used two methods in this study. The first of these was to use data from ITC's Export Potential Map website [29]. For each product group, we determined both the top ten countries in the world that show the highest demand for the product in question and the top ten countries where Türkiye can export the most easily. Product groups for which ITC does not make recommendations, we have determined a method as follows; first of all, we defined the first 15 countries with more imports than exports in that product group. Our basic idea in doing this was that these countries needed to import more from that product group in order to meet the demand in the domestic market. Afterwards, we calculated the Grubel-Lloyd index values of these 15 countries and determined the countries with the lowest index values in terms of imports. Finally, we tried to reveal the most suitable 10 countries by determining Türkiye's geographical proximity, current trade intensity, trade agreements and customs duties.

It would be appropriate to give some information in order to make things clear. We can try to explain it through the example of the product with GTIP code 560121. The total export potential of Wadding and Felts, including products coded 5601 and 5602, is 2.8 billion dollars worldwide by 2021. In other words, in addition to the current export, there is still the potential to realize such an amount of export. The unused export potential of the 560121 subgroup is 570 million dollars. Among the countries in the

world, the highest demand for this product group comes from the USA. It has been determined that the USA needs 48 million dollars more product in addition to the imports already realized from the product with the code 560121. It is followed by France, China, Russia and other countries on the list, respectively. The country with the biggest export potential of Türkiye is Russia with 4.1 million dollars. When Russia's geographical proximity, customs duties and current export volumes with Türkiye are included in the calculations, it turns out that it is the most suitable country with Türkiye. There are countries listed in the "World (Top 10 Countries)-USA, France, China, Russia, United Kingdom, Germany, Japan, The Netherlands, Canada, UAE" but not listed in the "Türkiye (Top 10 Countries)-Russia, France, Italy, The Netherlands, Ukraine, USA, Poland, Morocco, UAE, and Romania", such as Canada and Japan in the 560121 group. There could be several reasons for this. In the first place, it was not included in the list because exporting from Türkiye to that country may not be profitable enough due to geographical distance and customs duties. Another reason may be that it could not be included in the list because we exported to the country in question much more than it's potential. As a result, the countries in the lists are the countries with the highest export potential and the most suitable for export.

7. Market Shares and Market Volumes of Technical Textiles by Areas of Use

Technical textiles are classified according to their end-use areas by dividing them into 12 segments with the most accepted form in the world. These segments are summarized in Table 8.

Table 8. Technical textiles subcategories [11]

Agrotech (Agricultural Textiles)	Buildtech (Construction Textiles)
Clothtech (Technical Textiles)	Geotech (Geologic Textiles)
Homotech (Home Textiles)	Indutech (Industrial Textiles)
Medtech (Medical Textiles)	Mobiltech (Automotive Textiles)
Packtech (Packing Textiles)	Protech (Protective Textiles)
Sportech (Sport Textiles)	Oekotech (Ecologic Textiles)

Based on these segments, the global market shares and market volume realized in 2020 and expected to be realized in 2028 are given in Figure 7 and Figure 8 [26].

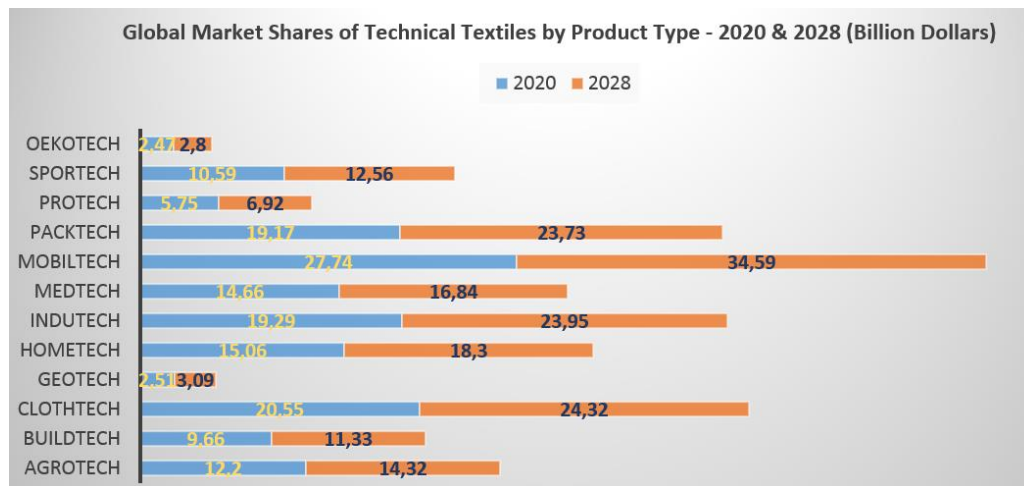


Fig. 1. Global market shares of technical textiles by product type in 2020 and 2028 forecast [26]

When we focus on the details of the tables, we can see that automotive textiles have the largest revenue share in the global market in 2020. In the period until 2028, it is revealed that automotive textiles (Mobiltech) will be the most important export item among all technical textiles. It is predicted that there will be a growth of approximately 24.69% in this segment until 2028. This segment is followed by industrial textiles (Indutech) with a growth rate of 24.15% and packaging textiles (Packtech) with a growth rate of 23.78%. As the fourth, the Clothtech segment is also expected to grow by 18.34%. In

terms of market volume, Mobiltech and Packtech again take the first two places. The comparison of prices per kilogram of these segments in 2020 and expected in 2028 and the expected rate of change are shown in Table 9.

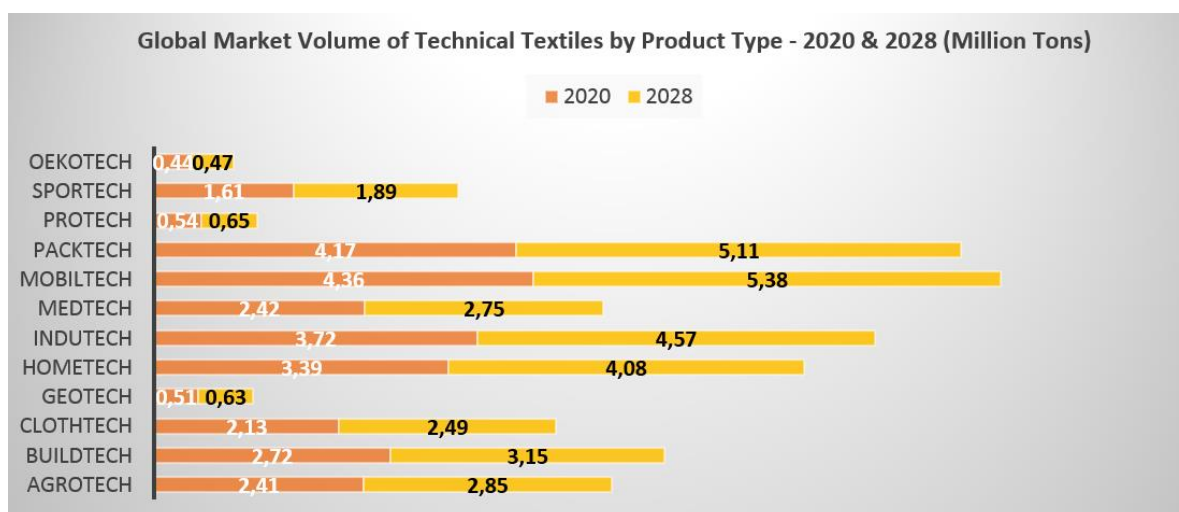


Fig. 2. Global market volume of technical textiles by product type in 2020 and 2028 forecast [26]

Table 9. Technical textiles price/kg in 2020, expected in 2028, and expected rate of change [26]

PRICES PER KG BY PRODUCT GROUP	PRICE PER KG IN 2020 (\$)	PRICE PER KG IN 2028 (\$) (Expected)	EXPECTED RATE OF CHANGE (%)
OEKOTECH	5.61	5.95	6.06
SPORTECH	6.57	6.64	1.07
PROTECH	10.648	10.646	-0.02
PACKTECH	4.59	4.64	1.09
MOBILTECH	6.36	6.43	1.10
MEDTECH	6.05	6.12	1.16
INDUTECH	5.18	5.24	1.16
HOMETECH	4.44	4.48	0.9
GEOTECH	4.92	4.90	-0.41
CLOTHTECH	9.64	9.76	1.24
BUILDTECH	3.55	3.59	1.13
AGROTECH	5.06	5.02	-0.79

The most important finding in the table is the expectation that ecological textiles will increase the most by 2028. In fact, the expectation that ecological textiles will increase to such a degree cannot be considered a surprising result. In the last two decades, we have witnessed that necessary steps have been taken in all sectors in order to achieve sustainability goals in developed economies. Furthermore, with the European Green Deal announced by the European Commission in 2019, a series of measures were announced to reduce carbon emissions rapidly and to reach the "net zero carbon" target by 2050. Demonstration of similar efforts by the USA and China and the inevitability of a major transformation in the industry in order to achieve these targets will greatly increase the demand for ecological textiles. The "border carbon" application, which is expected to be put into effect in 2026, and the additional tax obligations that this will bring to the producers of third countries trading with EU member states will act as an engine for bringing ecological textiles to the top. However, in emerging economies, the lack of awareness infrastructure is one of the main factors that make it difficult for this segment to grow. However, with the changing government policies, it is expected that the steps taken by the industrial sectors towards sustainability and environmental protection institutions will pave the way for more efficient adoption of ecological textiles.

8. Growth Factors and Market Trends in Technical Textiles

The fastest growing area of the textile industry in recent years is undoubtedly technical textiles. Global demand is increasing in this field, where strength, technical features and performance come to the fore rather than aesthetic concerns. We can predict that technical textiles will increase in importance in the coming years and become one of the important export items for Türkiye's textile industry. Close contact with the leading sectors of the country such as automotive, construction, defense industry and aviation and its capacity to supply products to these sectors stand out as the main factors that will pave the way for Türkiye's rapid rise in this field. The fact that developed and rapidly developing economies make significant investments in technical textiles is an indication that these products will play an important role in the future.

The critical issue for Türkiye at this point is that it focuses on the production of product groups with high added value within technical textiles. The comparison between China and Germany, which mentioned earlier, is instructive in this sense. Using the advantage of its 1.4 billion population and low production costs, China carries out trade in a larger volume by focusing on the production of technical textile products with relatively lower technology, and thus ranks first in technical textile exports in the world. We can see a similar trend in India for the last few years. India, just like China, has achieved a growth rate of 33.16% in this field in 2021 with its high population and low production costs, as well as the production and export of technical textiles with relatively low added value. Thus, India reached the highest growth figure in technical textiles last year. The importance attached to textiles in India can also be understood from the fact that the country has a government-level Textile Ministry.

On the other hand, unlike these two countries, Germany, with its 83 million population, produces technical textiles with higher technology and high added value, making it the second highest exporter country after China in this field. Germany's capacity to supply technical textiles to other sectors such as automotive and aviation seems to be higher than other countries. Although the production costs are much higher than in countries such as China and India, the strength of the bond established with different sectors and the synergy arising from this carry the technical textile sector of Germany to a very advanced level. If Türkiye, whose textile sector is traditionally strong, can increase the relations between different industries and use technical textiles effectively in this field, it can easily remove its lower population and medium-high production costs from being a disadvantage (Belgium, which ranks among the top ten in the world in technical textile exports with a population of 11.5 million, is an important example). Especially in parallel with the increase in freight prices with the COVID-19 pandemic, European companies' preference for their closer neighbors such as Türkiye to buy products instead of the Far East has an effect that will increase the growth in technical textiles.

9. Conclusions and Forecast of the Technical Textile Industry

The future of the technical textile industry in Bursa and Türkiye is affected by global developments. The two most influential include "Sustainability" and "Industry 4.0".

Sustainability

The 17 Sustainable Development Goals were set by the United Nations in 2015 and describe the necessary developments worldwide to achieve a better and more sustainable future for all. The most appropriate targets for the technical textile industry are 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities) and 12 (Responsible Consumption and Production). Sustainability for the technical textile industry sets new requirements for in terms of selection of raw materials, production processes and the design of existing and new products. The raw materials used for technical textiles must be sustainable and cannot be based on unsustainable fossil sources such as waste crude oil. Instead, agriculture, the most abundant source of sustainable raw materials, needs to be used. A trend is emerging for technical textiles to use more naturally occurring fibers such as cotton, jute, linen, as well as semi-synthetic cellulose-based polymers such as viscose. Synthetic fibers used for technical textiles will need to be made from monomers derived from sustainable sources such as agriculture. Some commonly used polymers such as PET and PE can be made from bio-based monomers, but newer polymers such as polylactides (PLA), poly (hydroxy alkenoates) (PHAs) and poly (ethylene 2,5-furandicarboxylate) (PEF) will also be introduced. These new polymers exhibit new properties and

therefore the technical textile industry will need to adapt to them. It can be said that the share of raw materials obtained from the recycling of previously used and expired products will increase; these raw materials may not be of the same quality as newly sourced raw materials, which will affect their properties. Furthermore, the production process needs to be sustainable. This means that sustainable sources such as renewable energy and bio-based auxiliary materials such as treatment agents and dyes must be used and their use should be minimized. The manufacturing process also needs to minimize waste generation by optimizing the process and switching to additive manufacturing whenever possible. Finally, the end product must be designed considering recycling, so that after its end of life it can be reused for other purposes or converted into raw materials for the same or other products ("cradle to cradle"). The product must have a minimum number of different parts that can be broken down into separate parts that can be easily reused or recycled, must be reused or recycled separately, and must contain no parts that cannot be recycled due to the components it contains.

Hopefully the customers of the new center will need services to assist them as below:

- Introduction of new bio-based raw materials for their products;
- Introduction of new bio-based excipients in manufacturing processes;
- Optimization of the production process, minimizing the use of raw materials and energy and waste generation;
- New product design according to "cradle to cradle" principles;
- Life Cycle Assessment services. This is because technical textile manufacturers will also have to present these evaluations to their customers;
- Market research services for new sustainable products.

Third and Fourth Industrial Revolution

The third industrial revolution, digitalization, enters a new era with the fourth revolution, interconnection, data power and artificial intelligence (Industry 4.0). The technical textile industry needs to adapt to these revolutions and take advantage of the opportunities to maintain its competitiveness by adapting it to the production process and the products it makes. Production will need to be further automated with the introduction of connected devices that use artificial intelligence (both quantitative and qualitative) to optimize production. It has also become a necessity that production can be adapted to the individual needs of each customer. Incorporating Industry 4.0 functions, such as the Internet of Things, into new products may be attractive in this sense. The business models used can also be made innovative. Türkiye is implementing the "Digital Transformation and Innovation in Technical Textiles" project with the support of the Ministry of Commerce. 14 technical textile companies have invested in their digital transformation to promote Industry 4.0 concepts through product development projects [30].

Hopefully the customers of the new center will need services to assist them as below:

- Introducing new digitized production processes using optionally interconnected production devices and artificial intelligence. These services can be offered in cooperation with Bursa Model Factory;
- Introduction of Industry 4.0 concepts in new products.

In the qualitative research part of our market research, where we conducted deep interviews with key actors operating in the sector, it would be appropriate to mention some of the prominent issues here in terms of showing growth factors. Particularly, due to the higher technology of technical textiles compared to conventional textiles, the need for trained personnel comes to the fore. Although a generation that has graduated from departments of universities such as textile engineering, mechanical engineering and industrial engineering and has a command of their own fields is already working in the sector, technical textile production makes it necessary to bring together the know-how in these different fields. Therefore, the existence of programs specific to this field in universities stands out as a need. Secondly, it seems inevitable that especially large-scale companies will attach greater importance to R&D activities. One of the keys to growth is to use R&D beyond just developing a product, to develop new technologies and applications, and to act with the awareness that these processes are long-term, tedious and require patience.

In Table 10, the growth factors and market trends of technical textiles on the basis of segments can be examined. Undoubtedly, growth is inevitable in every segment, but especially for Türkiye, automotive textiles, construction textiles and home textiles have a great growth potential in the next few years.

Nonetheless, investments in agricultural textiles, protective textiles and ecological textiles will bring significant gains for the producers and the country's economy in the not-too-distant future.

Table 10. Growth factors and market trends of technical textiles based on segments

Agrotech (Agricultural Textiles)	→ The capacity to produce responses to the negativity caused by global warming and climate change in the agricultural field. Good agricultural practices are becoming increasingly important all over the world
Buildtech (Construction Textiles)	→ Increased public spending on the development of housing and industrial infrastructure, which is increasing in all countries
Clothtech (Technical Clothing)	→ Today, the production of wearable electronics and especially heat-sensitive fabrics is becoming increasingly widespread
Geotech (Geological Textiles)	→ The acceleration of urbanization and the increase in the budget allocated for infrastructure investments
Homotech (Home Textiles)	→ An increasing population worldwide, an increase in housing construction and an increase in the demand for home textiles by end consumers
Indutech (Industrial Textiles)	→ The rapid industrialization of the world, supported by the latest technological innovations, increase the demand for high-performance materials, including technical textiles, in the industrial sector
Medtech (Medical Textiles)	→ Increased awareness of the growing need for medical textiles and better health practices, especially with the COVID-19 pandemic
Mobiltech (Automotive Textiles)	→ It is the automobile industry that tends to grow, especially with electric and hydrogen vehicles → Increased use of products such as seatbelts, airbags, automotive carpets → Developing engine safety regulations
Packtech (Packing Textiles)	→ With the increasing production trade activities between the borders, the increase in demands for durable flexible packaging materials → Increasing environmental concerns are creating a potential demand for sustainable packaging
Protech (Protective Textiles)	→ Increasing demands on personal safety, lightness and high strength in the defense industries of the world
Sportech (Sport Textiles)	→ The increase in demand for performance clothing along with the growing consumer interest in various sports activities
Oekotech (Ecological Textiles)	→ To be able to produce a response to new regulations and expectations with the European Deal → The capacity to produce products for the sustainability goals and needs of the circular economy

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