NATIONAL RESEARCH UNIVERSITY
HIGHER SCHOOL OF ECONOMICS

Yulia V. Milshina, Daria A. Pavlova,
Konstantin O. Vishnevskiy

FORECASTING THE INDUSTRY FUTURE THROUGH TIMELINES AND WILD CARDS: THE CASE OF TEXTILE AND APPAREL INDUSTRY

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Yulia V. Milshina[1], *Daria A. Pavlova*[2],

Konstantin O. Vishnevskiy[3]

FORECASTING THE INDUSTRY FUTURE THROUGH TIMELINES AND WILD CARDS: THE CASE OF TEXTILE AND APPAREL INDUSTRY[4]

Manufacturing today is undergoing fast and fundamental changes due to the introduction of Industry 4.0 technologies. Still, the effects of their applications on the global economic and social structure (in terms of risks and benefits) are highly uncertain. This paper is aimed to suggest a special methodology for conducting industry foresight based on timelines construction, which reflects future vision of technological development, and wild cards detection, which represents an advanced technique for technological trends risk management. In this way, we analyze the existing practices of timelines building and wild cards analysis for industry purposes in the academic literature, and suggest own methodology for conducting industry foresight by using these tools. To demonstrate its application, we choose a particular industry with great potential for technological innovation and high degree of uncertainty – the textile and apparel industry. Finally, we discuss future development of this industry at a national level in the context of global technological trends.

JEL Classification: O14, O32

Keywords**:** technological trends, timelines construction, wild cards detection, industry foresight, textile and apparel industry

[1] National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Leading expert; E-mail: ymilshina@hse.ru

[2] National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Research assistant; E-mail: dpavlova@hse.ru

[3] National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Head of unit for digital economy studies; E-mail: kvishnevskiy@hse.ru

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1. Introduction

Global manufacturing is characterized by rapid digitalization caused by the introduction of Industry 4.0 technologies. They are expected to increase the manufacturers' efficiency by decreasing their costs and delivering new value for the customers at a micro-level, and stimulate their involvement into global value chains and productivity at a macro-level. At the same time, these technologies bring new risks such as rise of unemployment and data security issues. Thus, the future of their industrial applications is highly uncertain (Heinemann, 2018).

In this regard, foresight as a scientific tool of future exploration might be of essential importance for the investigation of industry development. For the purpose of our research we use foresight methods for the investigation of the future of the textile and apparel industry, which at the moment undergoes fast and fundamental changes because of the introduction of Industry 4.0 technologies (Tsai, 2018; Duarte et al., 2018; Bertola, Teunissen, 2018; Chen, 2019). Nearly 60% of manufacturers in this sector have already invested in cloud technologies, connected devices and data analytics, while almost the same share requires the investments in augmented reality (AR) and artificial intelligence (AI) (WTiN, 2018). The possible industry-specific application of these technologies include such new materials as intelligent yarns, smart textiles etc. (LEAD, 2018). However, the future risks and benefits of these applications are highly uncertain at the moment.

Most studies (Keenan et al., 2004; Saricam et al., 2013, 2014; Oxxborrow, 2015) examined the 'textile and apparel industry' or 'textile and clothing sector' in general, without referring to the specific processes or products. However, Allwood et al., 2008 provided a scheme of the industry's with key elements – resources, products and processes. For our work we do not limit strictly the borders of the industry and use the classification suggested by Allwood et al. (2006, 2008).

Considering the extremely limited knowledge of strict predictive forecasts as well as the highly determined character of planning (Vishnevskiy et al., 2019; Milshina, Vishnevskiy, 2018), the research question of the study is *what is the most appropriate set of the foresight tools for understanding the future of textiles and apparel industry?*

For the response to our research question, we conducted a bibliometric analysis that allowed us identifying and examining papers describing methodological instruments used for the foresight of textile and apparel industry. Then we suggested several new methods that were underutilized in previous studies such as wild cards and timelines. After that we held 2 workshops and 10 interviews (with the participants of these workshops) that helped us to classify and assess global trends of the textile and apparel industry development (identified during the bibliometric analysis) as well as identify wild cards and opportunities and threats of the global trends for the national industry (Russian case study). On the basis of the achieved results we constructed the timeline which showed trends, the most relevant future events for each trend, wild cards (the events that may change drastically the global or national trends development), as well as opportunities and threats for the Russian textile and apparel manufacturers, brands and retailers.

This study, therefore, is aimed to develop a special methodological toolkit for conducting industry foresight including timelines construction and wild cards detection and demonstrate its applicability for the textile and apparel industry. To achieve this goal, in the next section we provide a brief analysis of previously conducted foresight studies on the textile and apparel industry. After that, in the second section, we explain the suggested advanced methodology for conducting industry foresight, and, in the third section, – to illustrate its applicability. Finally, in the fourth section we discuss the possible development of this industry in Russia in the context of global trends (identified and represented at a timeline) and wild cards.

2. Methodology

First of all, we conducted an analysis of existing literature and then examined papers describing methodological instruments used for the foresight of textile and apparel industry by the following criteria: scope, aim and results of research, time horizon, description of the methodology and methods used. Then advantaged and disadvantages of methodological instruments from these studies were identified and on this basis we suggested to add a creativity-based method – wild card analysis and a more systemic method which combines different dimensions on the Popper diamond (2008) (evidence, interaction, creativity and expertise) – a timeline. Timelines represent the future vision of development, or trends (Rosenberg, Grafton, 2013; Brehmer et al., 2016). To construct the timelines and conduct wild card analysis, we employed a balanced and comprehensive approach based on a number of foresight methods: bibliometric analysis (Gibson et al., 2019; Bootz et al., 2019), or qualitative evidence-based technique of document analysis, and wild cards detection (Qi et al, 2018; Pavlova et al., 2018; Meissner et al., 2019).

We held 2 workshops with 32 experts. At the workshop experts attributed a number of opportunities and threats for the Russian textile and apparel manufacturers, brands and retailers to each of the trend. Also at the workshops the wild cards of textile and apparel industry development were identified. Then 10 participants of the workshops took part in interview where they were asked to classify global trends (distinguished by us during the bibliometric analysis) by their probable time period and assess the possible influence of global trends on national manufacturers in terms of opportunities and threats according to the Likert scale (1 – low; 5 – high). The experts also offered the most relevant future events which confirm the appropriate global trends.

2.1. Bibliometric analysis

At first, general keywords such as “foresight” or “future studies”, or “forecast” in combination with “industry” were used to search the WoS database (Table 1). Web of Science includes all journals that are listed in the Science Citation Index Expanded (SCI-EXPANDED), and it thus provides a sufficiently broad range of literature. Secondly, we selected studies on the basis of the relevant search query addressed to WoS database ((textile* OR apparel* OR cloth*) AND (trend* OR future* OR forecast*)) for 2004-2019 years. The set of keywords then was refined iteratively using high-frequency keywords from the literature obtained (Table 2).

Table 1. Search query 1 and result count

Query 1	TI = ((“foresight*” OR future* OR forecast*) AND (industr* OR segment* OR sector*)) AND TS = (((trend OR data OR text) AND mining) OR “trend detection” OR “technolog* forecast*” OR “technolog* intelligence” OR “technolog* opportunit*” OR “emerging topic*” OR “topic detection” OR “topic tracking”)
Result count	452

Table 2. Search query 1 and result count

Query 2	TI = ((“trend*” OR future* OR forecast*) AND (textile* OR apparel* OR cloth*)) AND TS = ((trend OR tendec* OR “trend detection” OR “technolog* forecast*” OR “technolog* opportunit*” OR “emerging technolog*”) AND “textile* OR apparel* OR cloth*))
Result count	83

After that we reviewed each paper manually (535 papers in total), by reading its title and abstract. Papers that either did not address our research domain were removed. Papers that had connections to the industry foresight and textile and apparel domain were chosen as the basis for the further study and research in the field of methodology. A more detailed explanation of these studies with a special focus on the methodological issues is given below. Future studies about foresight for textile and apparel previously conducted in this area is presented in the Appendix A. They are briefly described in terms of year of launch, country origin, time horizon, aim, methodology and results.

2.2. Existing methodological approaches to future studies in the textile and apparel industry

The bibliometric analysis was based on analysis of papers devoted to the industry foresight (452 papers from the WoS database) and the papers where trends in textile and apparel were investigated (83 papers from the WoS database). At the intersection of these works we found the most relevant studies (13 papers) which became a basis for the analysis of the existing methodological approaches to future studies in the textile and apparel industry.

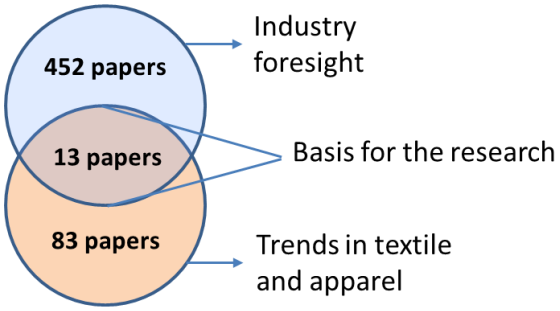


Figure 1. The scope of the bibliometric analysis

Conceptual framework of the studies' comparison (13 papers) was based on the investigation in details of the methodological tools in each research. We examined these papers by the following criteria: scope, aim and results of research, time horizon, completeness of methodology description and methods used. Then advantaged and disadvantages of their methodology were identified (Appendix A).

To start with, Keenan and his colleagues (2004) identified by themselves five key drivers of the EU textile and clothing sector (international trade relations, industrial organization and structure, new and emerging technologies, human resources, international rules and conventions). To explore the possible directions of the development, drivers were analyzed in three dimensions: "Alpha" outlook that involves simple extrapolation of current trends, "Beta" outlook which includes an opportunity that things "go wrong" and "Delta" outlook which contains "more visionary outcomes" (Keenan et al., 2004).

Allwood et al. (2008) also used scenarios to examine the UK textile and apparel industry. The analysis was conducted in three steps. Firstly, the current situation in this sector in the UK was described and possible scenarios were identified, compared and selected including case studies and quantitative predictions. After that, each scenario was assessed by means of predictive triple bottom line and represented with a "graphic equalizer". Than the results were reported to the stakeholders across the industry, who assessed the plausibility of each scenario again and gave feedback.

Two more studies based on the Godet's scenario planning (Godet, 2001) technique were conducted in Turkey (Saricam et al., 2013; Saricam et al., 2014). Firstly, scenarios were generated on the base of judgments of "foresighted and open-minded experts that have convenient backgrounds" and each scenario was matched with the initial hypothesis and assessed in terms of mathematical probability by means of cross impact matrix-multiplication applied to classification (MICMAC), matrix of alliances, conflicts, targets, objectives and recommendations (MACTOR) and cross impact systems and matrices (SMIC). The second part of the study included the experts' assessment of the key strategies that can be implemented for the advancement of the national industry (Saricam et al., 2014), (Okur, Saricam, 2019), (Saricam, Okur, 2019).

Oxborrow (2015) conducted a disaggregative Delphi survey (González-Sanmamed, Muñoz-Carril, 2019), (Agrawal, Pal, 2019) (a semi-quantitative method) the industry's experts. . The responses were compiled and validated through three rounds of the survey. The large scope of the survey, in contrast to its short time horizon (5 years), was explained by the author as a

relevant response to the rapid industry development (Oxborrow, 2015). Finally, a gap between retail strategy and supply chain practice was revealed, and three future scenarios of supply chains development were established: improved standardization and cost efficiency, proximity and flexibility, responsiveness to niche market demands.

Da Silveira Bruno and Pimentel (2016), in turn, focused the study on the technologies of Industry 4.0 and apparel sector in Brazil. The impact of the main disruptive technologies on four of the sector's strategic emphases (apparel, design, new fibers and new consumer channels) was investigated until 2030 (da Silveira Bruno & Pimentel, 2016). As da Silveira Bruno and Pimentel (2016) argued, the Greater Committee for the Brazilian Textile and Apparel Industry (CSITCB) was responsible for the specification of those four emphases. They were selected at the CSITCB meetings based on information gathered from the relevant consulting and academic studies, and interviews with small, medium and large enterprises. The ubiquitous technological trends, in turn, were identified by means of bibliometric analysis (Tian et al., 2018).

The study carried out in the EU (Bontoux et al., 2017) examined the future of the EU industry by means of the *Industrial Landscape Vision 2025* – a forward looking tool which has been already tested in previous foresight projects of the Joint Research Centre (JRC). It involved a number of workshops with a broad range of stakeholders. As a result, this study provided the description of the industry's key challenges grouped into four sectors (innovation resources, trade, skills) and recommendations for policy actions.

One more study on the future of the U.S. apparel market was held with the industry's experts, who answered four open-ended questions about the future of fiber, fabrics and other materials used for apparel production, production technologies, design and retail (Kim & Johnson, 2009). Such a survey, or interview, was chosen as a relevant method for receiving the in-depth predictions, views and ideas not constrained by several options. As a result, feedback from 62 professionals, who held the positions of production, sourcing, development, marketing and store managers, was obtained. The data was analyzed with the use of the constant comparative method and open coding, both of which allow examining, comparing and categorizing data according to the themes and sub-themes.

Lu (2015) and Foster (2016) examined the future of the U.S. knit apparel demand in next 20 years and the U.S. total textiles and apparel export to the world in next 10 years with the help of a mathematical univariate Box-Jenkins, or ARIMA analysis. This kind of modelling includes the analysis of time-series through autoregressive (AR) and meaning moving average (MA), and selection of the forecasting model which fits best for the current trends. The results of both studies represent statistical calculations of future knit apparel demand as well as the U.S. total textiles and apparel export.

Moreover, the EU SME Centre has recently released the report on the development of textile and apparel industry in China, which revealed not only its market size and structure, but the potential opportunities and challenges in both sub-sectors (textiles and apparel) (Irun B., 2017). Without referring to a specific foresight method, the authors of the study provided a detailed market and trend analysis with the use of a large scope of statistical data received from China National Bureau of Statistics, China Internet Network Information Center, Human Research Institute etc.

The environmental scanning was chosen as a key method by Kim et al. (2007) since it provides an opportunity to discover "emerging trends, situations, and potential pitfalls", which are of vital importance for such a dynamic environment. Having adopted the Stoffel's model, the researchers expanded its scope and divided the process into three stages. Firstly, they collected the information about the main areas: social, economic, competitive, technological, and political/regulatory areas. Secondly, they synthesized the emerging issues and evaluated their plausibility, impact, time of exposure and industry's responsiveness. Thirdly, the authors produced an in-depth report which was spread across the industry's stakeholders.

The technology assessment was employed to analyze the sustainability of the smart textile sector (Köhler, 2013). This kind of future-oriented activity shows the potential impact that an emerging technology may have on society, environment and economy (Nazarko, 2017). As it is argued by the author, the study can be characterized as an exploratory one with a qualitative interactive approach (literature review, consultations with stakeholders) due to the lack of robust quantitative data. Thus, it contains set of heuristics, which can be used as an anticipatory strategy for the production of smart textiles with the environmentally conscious design. To sum up, we checked which methods from the Popper's diamond (Popper, 2008) were used in 13 studies that we analyzed (table 3).

Table 3. The usage of foresight methods in existing papers for textile and apparel sector foresight

Foresight methods	**Existing papers**												
	Keenan et al., 2004	Kim et al., 2007	Allwood et al., 2008	Kim & Johnson, 2009	Saricam et al., 2013	Köhler, 2013	Saricam et al., 2014	Oxborrow, 2015	Lu, 2015	Foster, 2016	Da Silveira Bruno & Pimentel, 2016	Bontoux et al.,, 2017	Irun B., 2017
Literature review	+	+	+	-	+	+	+	+	-	-	+	+	+
Extrapolation	+	+	+	-	-	+	-	+	+	+	-	-	-
Scanning	-	+	+	-	-	-	-	+	-	-	+	+	+
Interview	-	+	+	+	+	+	+	+	-	-	+	+	-
Patent analysis		-	-	-	-	-	-	-	-	-	-	-	-
Cross impact analysis	-	+	-	-	+	-	+	-	+	+	-	-	-
Stakeholder analysis	+	+	+	-	-	+	+	-	-	-	-	+	+
Critical technologies	+	-	-	-	-	+	-	-	-	-	-	-	-
Quantitative Scenarios	-	-	+	-	-	-	-	+	-	-	-	-	-
Expert panel	-	-	+	+	-	+	+	+	-	-	+	+	-
Roadmapping	-	-	-	-	-	-	-	-	-	-	-	-	-
Delphi	-	-	+	-	-	-	-	+	-	-	-	-	-
SWOT	-	-	-	-	-	-	-	-	-	-	-	-	+
Survey	+	+	+	+	-	+	-	+	-	-	+	-	+
Timeline	-	-	-	-	-	-	-	-	-	-	-	-	-
Backcasting	+	-	+	-	-	-	-	-	-	-	-	-	-
Role play/Acting	-	-	-	-	-	-	-	-	-	-	-	-	-
Scenario writing	+	-	+	-	+	-	+	+	-	-	-	+	-
Gaming	-	-	-	-	-	-	-	-	-	-	-	-	-
Simulation	-	-	+	-	-	-	-	-	-	-	-	-	-
Science fiction	-	-	-	-	-	-	-	-	-	-	-	-	-
Wild Cards	-	-	-	-	-	-	-	-	-	-	-	-	-

2.3.Knowledge gaps in existing methodologies

The analysis showed that these studies (Appendix A) are predominantly based on several commonly used expert-based foresight methods (scenarios, interviews, expert panels/workshops etc.), whereas creativity-based techniques (wild cards, science fiction), are underutilized as well as the highly resource consuming methods such as roadmapping and patent analysis (see table 3).

By the criteria of methods used basically all studies are formed on the use of 5-12 types of tools, e.g. the studies by Kim et al. (2007), Kim & Johnson (2009), Allwood et al. (2008), Keenan et al. (2004). A lot of papers lack a detailed explanation of methods used (like Irun B. (2017), Da Silveira Bruno & Pimentel (2016), Keenan et al. (2004)). For example, in works of Saricam et al. (2013, 2014) there weren't any description of technique how authors selected experts. However these papers are based on scenario planning methods where the main focus is on experts' opinions.

By the criteria of the scope of the research most of the papers concern only national or regional markets of textile and apparel (EU – Keenan et al., 2004; Bontoux et al., 2017; Germany – Köhler, 2013; UK – Allwood et al., 2008; USA – Kim et al., 2007; Kim & Johnson, 2009; Lu, 2015; Foster, 2016; Brazil – Da Silveira Bruno & Pimentel, 2016; Turkey – Saricam et al., 2013, 2014). They all lack the analysis of global context of industry development (i.e. global trends analysis). Some authors state that they need further research for additional refinement and possible combination with quantitative approaches (Bontoux et al., 2017).

An overview of the previous foresight studies on the future of textile and apparel industry demonstrates that there are several underutilized methods, such as a trend analysis within a timeline and qualitative creativity-based techniques (wild cards etc.) (Figure 2).

Figure 2. Key characteristics of foresight methods

Source: Authors' analysis based on Popper (2008) and Vishnevskiy et al. (2015).

The most popular qualitative methods occurred to be literature review (bibliometric analysis), expert panels and scenarios, which were widely used by the scholars who examined the future of textile and apparel industry (Fig. 2). Popper (2008) noticed that creativity-based methods are much less commonly used that expertise- or evidence-based ones. This statement can also be illustrated by the figure above. Finally, the scholar assumed that the reason for this is the lack of guidance on how to apply techniques such as gaming and other creative methods like wild cards or weak signals.

The explanation of underutilized methods, including qualitative creativity-based (Skulimowski, 2016) in foresight studies seems to be especially true if we consider the costs and results of different methods. This idea was suggested by Vishnevskiy et al. (2015), who identified several groups of foresight techniques (low-cost, highly informative, resource consuming and highly specialized) based on these parameters. Low-cost methods (literature review, interviews, SWOT) are expedient for any foresight processes since they do not require considerable expenses, but achieve results which ensure the reliability of research. Highly informative methods (scenario writing, expert panel) are more expensive than the first ones, but their performance is much higher. Implementation of resource consuming methods requires significant financial, organizational and other resources (Delphi, roadmapping), however they are important for large businesses. Highly specialized ones (wild cards, backcasting) achieve specific positive effects, especially during the analysis of fast-changing and not always predictable environment, but they should be implemented in conjunction with trend analysis.

3. Further suggestion for methodological toolkit improvement

In our study we decided to improve the methodology developed by other researchers from this field and to add methods that were ignored in studies which we investigated. Our suggestion was to add such instruments as timeline and wild card analysis. Patent analysis and roadmaps were excluded because they are too resource consuming and we had no resources available to perform them. Science fiction method was excluded also because it is too specific. The steps of our analysis are described in detail below.

At the system level, an identification of wild cards plays an important role in constructing forecast scenarios by company or government in addition to a comprehensive trend analysis. The purpose of the analysis in this case is to test the stability of the system (foresight research) against unforeseen events with a high degree of influence (Mendonça et al., 2004). However, trends and wild cards study performs several more functions in the process of developing scenarios: it evaluates the sensitivity of the scenario to external influences, and compensates for the "weaknesses" of the scenario, including identifies its errors and identifies alternative potential ways of development. The identification of wild cards also allows introducing new elements into closed processes for forecast scenarios building, start a strategic discussion and go beyond standard solutions and actions (Pavlova et al., 2018). Thus, this study should be considered as an element that allows to increase the prognostic potential and adaptive abilities,

which is especially important for companies and government agencies that are forced to work in conditions of a high-risk and turbulent environment.

The best representation of the achieved results of trend and wild cards analysis can be done in the form of timelines. The timeline contains the results of the analysis of the key components of the industry: the main trends, the most significant future events, wild cards, challenges and opportunities (for company, industry, region or country).

3.1.Global trends analysis

We began from global trends, or megatrends, analysis because it sets the frame for further research and for the timeline building and wild card identification (Mikova & Sokolova, 2014). Global trends generally represent gradual forces, factors and patterns that are pervasively causing change in society (Saritas & Smith, 2011; Ena et al., 2016; Saritas, Proskuryakova, 2017). We used the expanded version of the PEST classification from environmental scanning research, sometimes also referred to as the STEP classification (Hiltunen 2008; Carr and Nanni 2009). This classification scheme distinguishes between political, economic, ecological, social and technological (including scientific research and development) trends (STEEP).

We used bibliometric analysis to identify the most promising global trends for textile and apparel industry. 83 papers (from the step with bibliometric analysis based on WOS database) devoted to trends in textile and apparel industry were studied. We chose from them the most relevant global trends and classified them by STEEP (Table 4).

And then we verified our global trends' list with high-qualified experts from the field. The progress and results of the study were discussed with experts in two expert workshops that gathered 32 experts from Russian Ministry of Industry and Trade (15 persons), the Russian Union of Entrepreneurs of Textile and Light industry (13 persons), large companies (BTC Group, Tchaikovsky Textile) (4 persons). Participants of the workshops were asked to assess the possible influence of these trends on national manufacturers in terms of opportunities and threats according to the Likert scale (1 – low; 5 – high). Global trends detected by bibliometric analysis on previous step were classified by experts by their probable time period (the maximum progress of these trends' development): short-term trends – by 2020; medium-term trends – 2021-2025 and 2025-2030; long-term trends – after 2030.

Also at the workshop experts attributed a number of opportunities and threats for the Russian textile and apparel manufacturers, brands and retailers to each of the trend and connected event (Appendix D). Following opportunities were selected for the further expert assessment:

- ✓ business model innovation;
- ✓ product diversification;
- ✓ productivity growth;
- ✓ quality improvement;
- ✓ costs reduction.

And following threats for Russian textile and apparel manufacturers, brands and retailers:

- ✓ strong global competition;
- ✓ increased costs;
- ✓ safety hazard;
- ✓ technological complexity;
- ✓ lack of skills and competencies.

Next, we conducted 10 expert interviews with selected participants from the expert workshop (see the fulfilled questionnaire in Appendix C), and 2 of them were from large companies, 5 experts from Russian Ministry of Industry and Trade, 3 experts from the Russian Union of Entrepreneurs of Textile and Light industry.

3.2.Wild cards detection

We continued our research with analysis of wild cards and suggested timeline as a systemic instrument to visualization and analysis of trends, major future events and wild cards. According to Mendonça et al. (2004), "wild cards refer to incidents with perceived low probability of occurrence but with potentially high impacts and strategic consequences for an organization or a society'.

These incidents, or events, may vary by consequences (reversible/irreversible), process (long-term/sudden/black swans), plausibility (highly certain/imaginable and probable/imaginable but improbable/unimaginable), break type (dead end/slow end/dead end to a recovery to a trend line/push up in positive direction/slow push up in positive direction), topic (political/technological/economic/socio-cultural/environmental), life areas (surprise attack/technology and infrastructure upheaval/earth and sky/geopolitical and sociological changes/biomedical developments/spiritual and paranormal) and impact (personal/local/national/transnational/international/global).

Wild cards were detected during two workshops with experts. They were asked about events which can be 'bifurcation points' that cause a change of a trend development flow. We asked them to detect wild cards that satisfied the following criteria simultaneously.

- o Events have low probability of occurrence in the context of the prevailing trends.
- o Events might have high and, predominantly, global impact.
- o The impact of the events might be imposed on the whole society.
- o Events might change the direction of trends or time of their realization.
- o Events might create radically new opportunities and threats.

Then we asked experts to verify chosen wild cards and assess the level of their probability of realization (high, medium, low) and period of each wild card possible appearance (the same as for the global trends identification and timelines construction – 2017-2020; 2021-2025; 2026-2030) (Appendix E). Then the radar as the instrument of wild cards detection and representation was employed.

3.3.Timelines building

The next step was the timeline construction as the way to systematize trends, wild cards and promising events representation. According to Coelho et al. (2012), a timeline is "the representation of a temporal sequence of possible future events…that promote environmental changes, and alterations in the trajectories of relevant phenomena, defined by national and international studies, in order to support decision-making and the elaboration of policies and strategic plans."

Traditionally, timelines are commonly used in historical studies in order to reflect the sequence of events that already happened. In this way, the timelines that are used in future studies are different since they reflect the sequence of events that might happen in the future. Timelines in foresight studies are considered to be an alternative option for conventional scenarios, which are aimed to explore the different possibilities that may emerge in the future. Still, the timelines are supposed to reflect a fuzzier vision than the scenarios permit (Coelho et al., 2012). While comparing the timelines with other foresight methods, they also should not be confused with roadmaps. The roadmaps represent a graphical portray of the intended strategy of product or technology development, whereas the timeline is a graphical portray of its possible evolutionary pathways (Simonse et al., 2015).

An appropriate timeline can be built in several steps, which include the identification of the observation dimensions for modelling the future, the definition of the scope, or the main aspects, that should be considered, the detection of relevant future events within the determined timeframe and the search for future-bearing facts that may represent 'turning points' in observed trends. According to this theoretical framework, we built a timeline for the future of the textile and apparel industry in several steps described below.

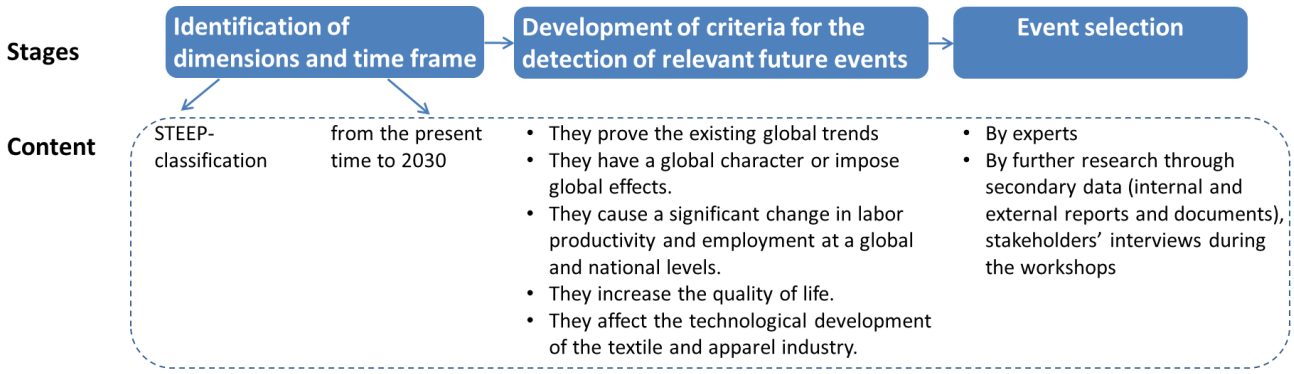


Figure 3. Stages of a timeline building

- Firstly, we identified a number of dimensions for observation using the same STEEP framework as for the analysis of the global trends. We also defined the time period of observation, which is also the same as for the analysis of the global trends (from the present time to 2030).
- Next, we developed several criteria for the detection of relevant future events within the determined dimensions and time frame. Particularly, we decided to consider the facts as 'future-bearing' ones if they satisfy the following criteria.

- The events prove the existing global trends for the textile and apparel industry which we've chosen and verified on the previous steps.
- The events have a global character or impose global effects.
- The events cause a meaningful change in labor productivity and employment at a global and national levels.
- The events considerably increase the quality of life.
- The events seriously affect the technological development of the textile and apparel industry.

- We asked experts to give for each trend a proving event which should satisfy the above-mentioned criteria. Those events that were missing after the expert interviews were supplemented by our research through secondary data (internal and external reports and documents), actor interviews during the workshops (Appendix C).

4. Key findings

Application of the methodological instruments described above allowed us to identify a number of global trends in the textile and apparel industry represented at the Table 3. Expert estimations of influence of opportunities and threats for the Russian textile and apparel industry are also presented below.

Table 4. Global trends analysis for the textile and apparel industry and its influence on Russian domestic textile and apparel sector development.

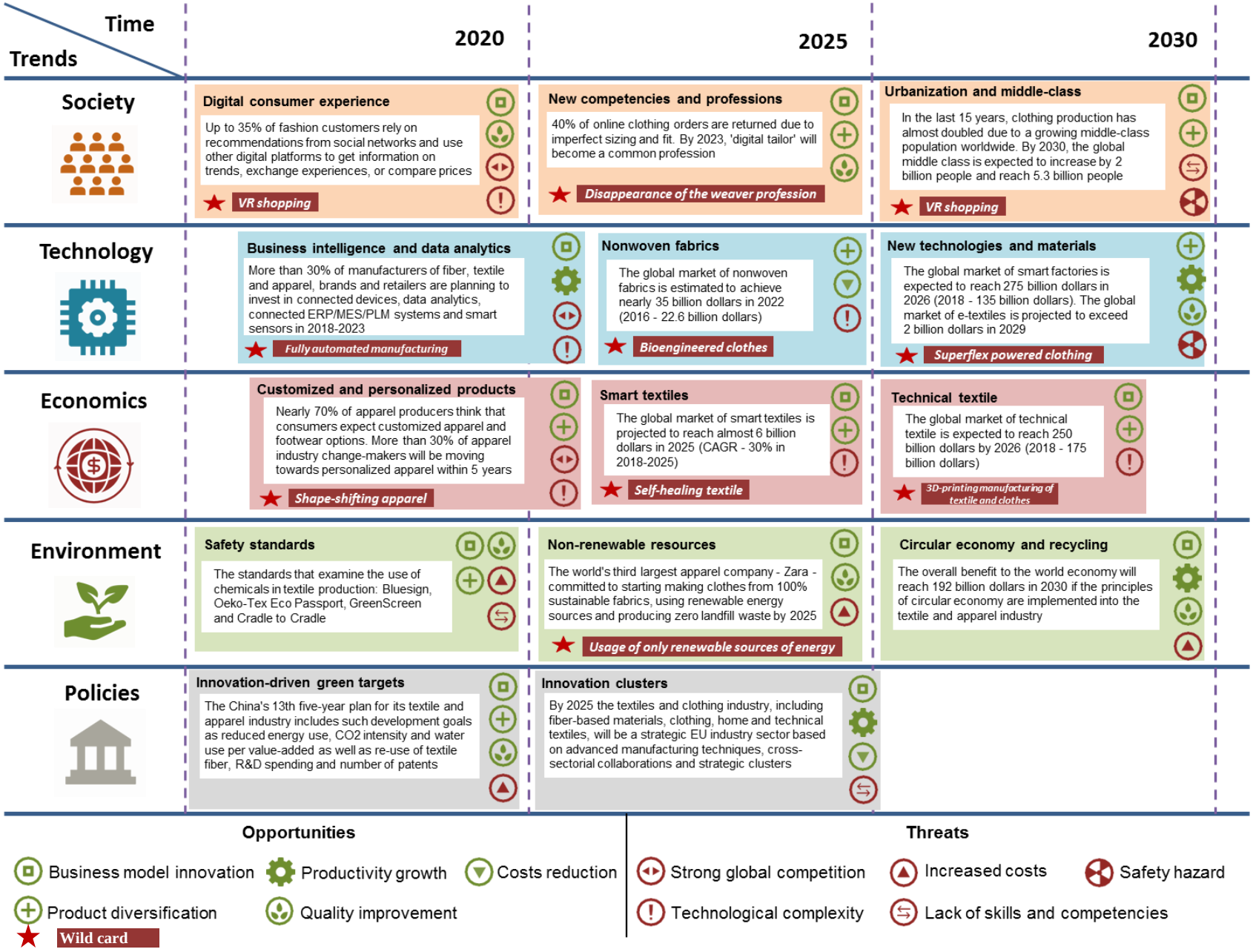
Area	**Brief description**	**Papers where a trend was described**	**Time period (2017 – 2030)**	**Influence (1 – low 5 – high)**	
		Results of bibliometric analysis (some examples)		**Opportunities**	**Threats**
Social trends	Digitalization of consumer experience	• Kim & Johnson, 2009; • Irun B., 2017.	2017 – 2020	✅✅◯◯◯	❌❌◯◯◯
	Emergence of new competencies and professions	• Kusters et al, 2017.	2021 – 2025	✅✅✅◯◯	❌◯◯◯◯
	Urbanization and growth of the middle-class	• Franco, 2017.	2026 – 2030	✅✅◯◯◯	❌❌◯◯◯
Technological trends	Improved business intelligence and data	• Kim & Johnson, 2009;	2021 – 2025	✅✅◯◯◯	❌❌◯◯◯

	analytics	• Saricam et al., 2013; • Saricam et al., 2014; • Da Silveira Bruno & Pimentel, 2016.			
	Development of nonwoven fabrics	• Kistamah et al., 2017.	2021 – 2025		
	Digitalization and robotization of manufacturing	• Irun B., 2017; • Pal, Sandberg (2017);	2021 – 2025		
	Introduction of radically new technologies and materials	• Bontoux et al., 2017.	2026 – 2030		
Economic trends	Increased demand for customized and personalized products	• Pal, Sandberg (2017);	2021 – 2025		
	Wide spread of smart clothes	• Irun B., 2017.	2021-2025		
	Development of small-scale manufacturing and its localization (‘re-offshoring’)	• Gornostaeva, Barnes, 2015.	2026 – 2030		
	Growth of technical apparel production	• Oxxborrow, 2015; • McCarthy, 2016;	2026-2030		
Environmental trends	Strengthening of environmental safety standards	• Almeida, 2015.	2017 – 2020		
	Reduction of usage of non-renewable resources	• Kirchain et al., 2015; • Nayak, Mishra, 2016.	2021-2025		
	Growth of circular economy and recycling intensification	• Köhler, 2013.	2026-2030		
Political trends	Setting innovation-driven green development targets	• Saxena, Khare, 2015.	2017-2020		
	Fostering collaboration among manufacturers and innovative clusters development	• Sohn et al, 2016; • Bontoux et al., 2017.	2021 – 2025		

To demonstrate the depth of the analysis of the global trends in the textile and apparel industry, we developed (or designed) *a timeline*, or a line of highly expected and plausible events as well as wild cards arranged in a chronological order and supported with a detailed explanation of the opportunities and threats of global trends for the national textile and apparel sector (Russian case) (Figure 4).

Timeline visualizes the dynamics of the global trends discussed earlier and possible wild cards. Moreover, figure 4 illustrates the character of the opportunities and threats (which number is represented in the Table 1) for the Russian textile and apparel manufacturers, brands and retailers, connected with the global social, technological, economic, environmental and political trends. More detailed explanation of these trends, opportunities and stakeholders that might be involved is represented in Appendix B.

Figure 4. Timeline for the future of the global textile and apparel industry



Source: Keller et al, 2014; Morlet et al, 2017; https://www.marketsandmarkets.com/Market-Reports/non-woven-fabrics-market-101727296.html; https://www.globenewswire.com/news-release/2019/06/11/1867169/0/en/Smart-Factory-Market-To-Reach-USD-275-89-Billion-By-2026-Reports-And-Data.html; https://www.grandviewresearch.com/press-release/global-smart-textiles-industry; https://www.globenewswire.com/news-release/2019/10/01/1923516/0/en/Technical-Textile-Market-To-Reach-USD-249-95-Billion-By-2026-Reports-And-Data.html

Regarding the opportunities, in a short-run the domestic producers and retailers of textiles and apparel are able to employ some innovative business models, diversify product range, increase productivity and quality of products due to 'digitalization' of consumer experience, improved business intelligence and data analytics, customized and personalized products, safety environmental standards and innovation-driven green development targets. In a mid-run, the Russian stakeholders may achieve almost the same effects as in a short-run, but also to reduce the costs by means of emergence of new professions and competencies, development of nonwoven fabrics, wide spread of smart clothing, reduced exploitation of nonrenewable resources and establishment of innovative clusters. In a long-run, these stakeholders might improve their business models, productivity and quality as well as diversify products due to the rapid global urbanization and middle class expansion, introduction of radically new technologies and materials into the manufacturing processes, increased production of technical apparel, development of circular economy and recycling intensification.

However, while exploiting the opportunities that accompany these global trends, it is important to consider the threats that might also appear. Particularly, the Russian manufacturers, brands and retailers may face a strong global competition in an attempt to digitalize the consumer experience, employ the professionals with new competencies, improve business intelligence and data analytics and customize or personalize products. Moreover, the Russian stakeholders might experience difficulties with the technological complexity of the consumer behavior digitalization, data analytics improvement, products personalization and customization as well as nonwovens, smart clothes and technical apparel production. Finally, the costs of the Russian stakeholders may increase significantly due to the strengthening of the environmental safety standards, reduction of the usage of non-renewable resources in favor of more sustainable ones, implementation of the principles of circular economy and alignment of the corporate strategy with the innovation-driven green targets set at the national level.

To improve the results of our analysis and demonstrate the application of creativity-based techniques to the investigation of the future of the specific economic sector, we demonstrate the results of wild cards analysis which helps to go beyond the standard solutions and introduce new elements into the "closed" processes of forecasting (Figure 5).

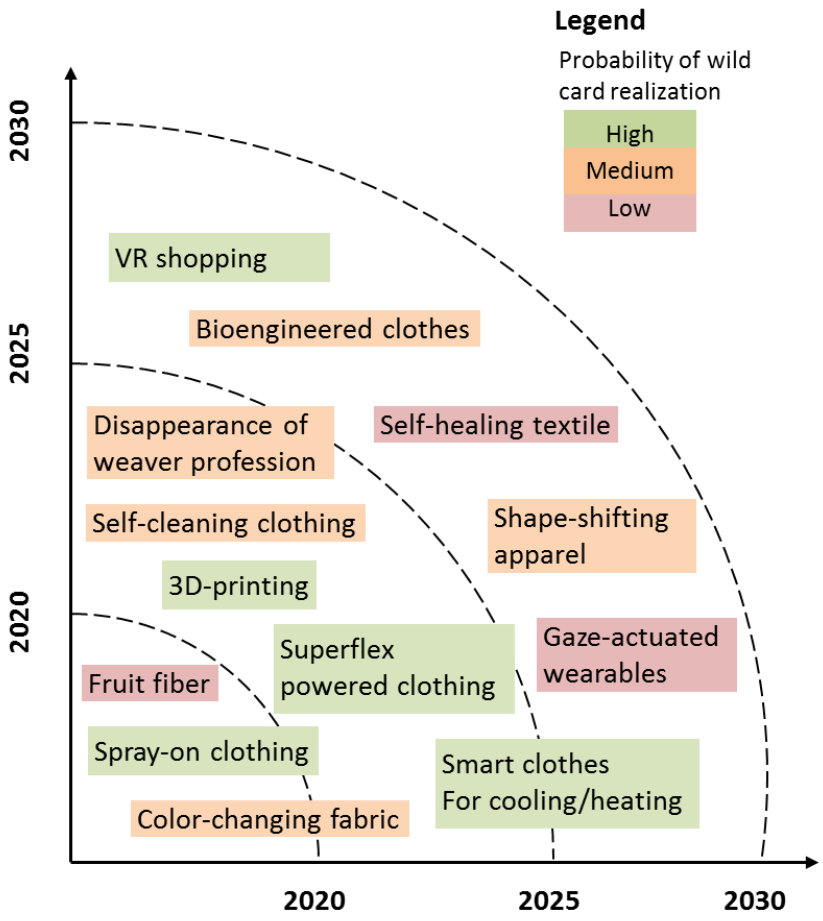


Figure 5. Radar of wild cards for the future of the global textile and apparel industry.

The Radar demonstrates several events with low probability of occurrence but high impact in case of happening, or wild cards. These events were identified for the same forecasting period as the global trends from the present time to 2030 with two more key milestones in 2020 and 2025. A detailed explanation of some of them as well as the consequences that they may cause is given below.

For example, the wide spread of VR technologies in the clothing industry can fundamentally transform the retail channels due to the emergence of virtual shops and fitting rooms, which, in turn, can seriously affect the consumer habits and behavior. Under these circumstances, it is highly likely that all shops, boutiques and malls will leave the physical space and mover to the cyber one. Another wild card, which also might contribute to the shops disappearance, is the mass application of 3D-printers to clothing production. The gradual decline in complexity, price and size of 3D-printing equipment may testify that in the nearest future all people would produce clothes at homes with their own designs. However, this event might be prevented by such wild card as the usage of food (e.g. fruits, vegetables, plants) for textile manufacturing, which means higher fashion sustainability along with radically new way of apparel production. Still, it seems almost impossible because of the expected mass adoption of smart clothing (self-restoring, self-cleaning, charging, shape-shifting, color-changing, heating etc. garments), which can completely deprive the fashion industry of seasonal changes.

To sum up, this chapter demonstrates a number of key findings of our study: a list of global trends that can fundamentally change the future of the textile and apparel industry in the next 10-20 years classified by STEEP framework. Global trends are accompanied by the assessment of their influence on the Russian stakeholders of this economic sector; a timeline of these trends supported by some meaningful events that approve their direction and time of realization and detailed explanation of the character of the opportunities that the Russian stakeholders may exploit from it in the future as well as the threats that may prevent them from it; a radar of wild cards which can considerably affect the future of the textile and apparel industry at the global and national levels, change the direction and time of realization of the suggested global trends and create radically new opportunities and threats.

5. Discussion

Selected and verified global trends, wild cards and the timeline serve for the purpose of creating the picture of global trends development. The timeline is a way to show on the one picture different trends' flows and possible ways of its unexpected changes (wild cards). Also this analysis includes estimations of opportunities and threats for the Russian textile and apparel manufacturers, brands and retailers. These opportunities and threats appear during the trend realization and should be taken into account in order to use its effects and mitigate possible risks. Thus, these instruments can be used by different stakeholders (on government, company, non-commercial, academic and scientific level) during the foresight process for the particular industry.

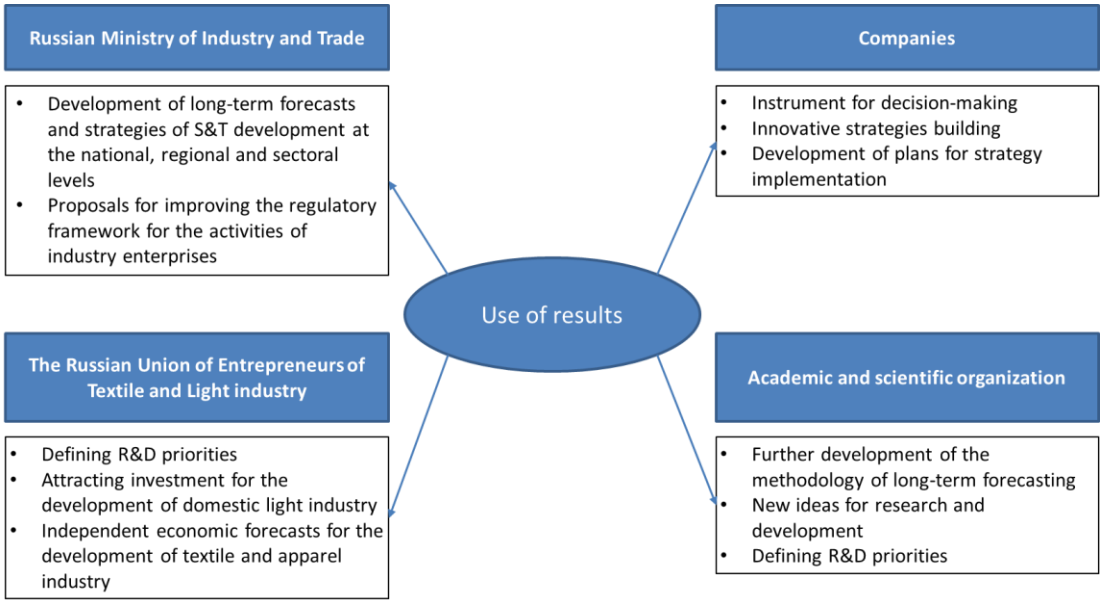


Figure 6. The use of research results by various stakeholders.

For our pilot application, we highlighted such global trends, wild cards, opportunities and threats which weren't included into the projects of national strategy of textile and apparel industry development. These trends require clarification in terms of opportunities that can be captured and possible policy actions, which are taken. On the basis of the analysis conducted in the previous section, the underinvestigated trends in the Russian textile and apparel industry are

considered to be the industry's rapid technological advancement and related economic and social transformations and transition to circular economy.

There is a great potential of application oa new industrial revolution technologies to the textile and apparel industry. To start with, the use of dig data and analytics and, correspondingly, IoT systems can definitely address the problem of illegal, or "gray", import and counterfeit products due to the processing of huge amounts of ecommerce data and anomaly detection among their usual patterns (McEleny, 2018). At the same time, the combination of these technologies with cloud computing can increase the speed of data processing, the efficiency of data storage and the quality of analysis (Cai et al., 2017). In addition, the introduction of IoT and big data into the Russian clothing industry can significantly foster the algorithmic trade and, therefore, spread of new marketing practices (e.g. emotional trading) and business models (e.g. sharing platforms).

Moreover, the implementation of additive manufacturing technologies can considerably contribute to the production localization and decentralization (Ben-Ner & Siemsen, 2017). This means that production facilities are expected to be removed from those places where cheap labor force has previously played the key role (Asian countries) to those places, which are near to the customers and local market (Jiang et al., 2017). This change will also satisfy the growing demand for customized and personalized goods that are anticipated to be produced in a much shorter periods of time with much less amount of resources being used for its production and higher level of accuracy. Furthermore, such kind of transformation will cause a considerable decrease in logistics costs. Taking into consideration the opportunities of autonomous robots, which can easily substitute man's labor in manufacturing, especially additive one, the production costs are expected to be significantly minimized and competitive advantage achieved.

Finally, the image and prestige of domestic apparel brands can be improved by means of AR technologies. Many well-known European brands have already launched mobile applications with AR functions, which allow them to see the garments all the way around, create and share own designs and even watch holographic versions of catwalk shows on the smartphones (Arthur, 2017). Overall, these innovations are considered to be an effective way to increase brand value through immersive storytelling, playful and interactive approach (Arthur, 2017).

Regarding the policy actions that have been taken in order to facilitate the transition of the Industry 4.0 principles to the Russian industry in general, an important role of the state program "Digital Economy of the Russian Federation" (2017) should be highlighted. The Russian federal authorities suggested complex development of core technologies (big data, AI, blockchain, quantum computing, new production technologies, industrial internet, robotics and sensory, wireless communication, AR/VR) and related platforms, which are used for the establishment of new competencies which satisfy the requirements of new markets.

The second trend of the Russian textile and apparel industry development, which was detected in this study, but attracted less attention from the Russian public authorities as well as the non-commercial sector is circular economy. This relatively new direction of global economic development is considered to be one of the main forces driving the expansion of Industry 4.0 because of its essential need to reduce the amount of raw materials involved in production, reuse products several times, recover their value and recycle the waste (Pakhomova et al., 2017). For

these reasons, such digital technologies as computer modelling and engineering, additive manufacturing and robotics, IoT and cloud computing, seem to have great potential for the increase of accuracy and decrease of time of production as well as exploitation of biodegradable materials (Zeidler et al., 2018). Regarding the policies that facilitate the development of circular economy in the Russian industry, domestic scholars mention several federal laws, which regulate the waste issues (Pakhomova et al., 2017), and a special Strategy for waste recycling industry in the Russian Federation up to 2030 (2018). The main principles of this strategy also seem to be relevant for the improvement of the existing Strategy for the light industry development in Russian Federation up to 2025 (2015).

6. Conclusion

Tis paper represents a comprehensive overview of future development of the textile and apparel industry at a global and national level. The previous foresight research on this topic demonstrated the heterogeneous character of foresight methods applied to the investigation as well as the imbalance between the creativity-based and other types of techniques.

An analysis of wild cards increases the probability to succeed in prevention of the negative consequences of these events. Also they help to predict various scenarios of global and national trend development. It has a positive influence of managerial efficiency. If such an analysis is not carried out, there is a risk of incurring high time costs in the process of crisis management, for which stakeholders (companies, government, non-commercial organizations, consumers) were not ready, or to face the problem with a lack of managerial competencies to solve the problem or without a choice of an inadequate response tool. A preliminary analysis of unforeseen events with a high potential of disruption can help save resources and time that are used to manage a crisis situation. Actors may pay more attention to solving other management tasks.

The timeline helps to form a picture of the future. It includes global and national trends classified by STEEP as well as wild cards related to each trend and opportunities and challenges of global trends development for stakeholders on national level. The timeline is aimed at increasing the efficiency of the decision-making process in the field of trend prioritization. It gives an idea of the composition and size of markets, potential opportunities and threats at different time intervals, and facilitates the process of constructing scenarios for the development of the region. The timeline can be used to develop and implement state policy in the relevant field, in the work of various federal executive bodies, industry associations, technology platforms, innovative territorial and scientific-production clusters, in the formation of state programs, industry development programs, etc.

To identify the opportunities and threats for the industry development, we suggested comprehensive methodology based on timelines construction, which reflects future vision of global trends (social, economic, ecological, political, technological), and wild cards detection, that represents an advanced technique for global trends risk management.

References

Agrawal TK, Pal R. (2019). Traceability in textile and clothing supply chains: Classifying implementation factors and information sets via Delphi study. Sustainability. 2019 Jan;11(6):1698. (date of access: 05.11.2019)

Allwood, J., Laursen, S., Rodriguez, C., Bocken, N. (2006). Well Dressed? The Present and Future Sustainability of Clothing and Textiles; University of Cambridge, Institute for Manufacturing: Cambridge, UK, 2006.

Allwood, J., Laursen, S., Russell, S., de Rodríguez, C., & Bocken, N. (2008). An approach to scenario analysis of the sustainability of an industrial sector applied to clothing and textiles in the UK. *Journal of Cleaner production*, *16*(12), 1234-1246. (date of access: 01.11.2019)

Almeida, L. (2015). Ecolabels and organic certification for textile products. In Roadmap to Sustainable Textiles and Clothing (pp. 175-196). Springer, Singapore. (date of access: 05.11.2019)

Arthur, R. (2017). Augmented Reality Is Set To Transform Fashion And Retail. [Electronic resource] URL: https://www.forbes.com/sites/rachelarthur/2017/10/31/augmented-reality-is-set-to-transform-fashion-and-retail/#ba301963151d (date of access: 05.11.2019)

Ben-Ner, A., & Siemsen, E. (2017). Decentralization and localization of production: The organizational and economic consequences of additive manufacturing (3D Printing). California Management Review, 59(2), 5-23. (date of access: 05.11.2019)

Bertola, P., & Teunissen, J. (2018). Fashion 4.0. Innovating fashion industry through digital transformation. Research Journal of Textile and Apparel, 22(4), 352-369. (date of access: 05.11.2019)

Brehmer, M., Lee, B., Bach, B., Riche, N. H., & Munzner, T. (2016). Timelines revisited: A design space and considerations for expressive storytelling. IEEE transactions on visualization and computer graphics, 23(9), 2151-2164. (date of access: 05.11.2019)

Bontoux, L., Boucher P. and Scapolo, F. (2017). Textiles and Clothing Manufacturing: Vision for 2025 and Actions Needed, EUR 28634 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-69301-4. (date of access: 02.11.2019)

Bootz JP, Durance P, Monti R. (2019). Foresight and knowledge management. New developments in theory and practice. Technological Forecasting and Social Change. 2019 Mar 1;140:80-3. (date of access: 05.11.2019)

Cai, H., Xu, B., Jiang, L., & Vasilakos, A. V. (2017). IoT-based big data storage systems in cloud computing: Perspectives and challenges. IEEE Internet of Things Journal, 4(1), 75-87. (date of access: 05.11.2019)

Chen CL. (2019). Value Creation by SMEs Participating in Global Value Chains under Industry 4.0 Trend: Case Study of Textile Industry in Taiwan. Journal of Global Information Technology Management. 2019 Apr 3;22(2):120-45. (date of access: 05.11.2019)

Coelho, G. M., Galvão, A. C. F., Guedes, A. C., Carneiro, I. A., Chauke, C. N., & Filho, L. F. (2012). Strategic foresight applied to the management plan of an innovation development agency. Technology Analysis & Strategic Management, 24(3), 267-283. (date of access: 05.11.2019)

Da Silveira Bruno, F., Pimentel F. (2016). Apparel manufacturing 4.0: a perspective for the future of the Brazilian textile and apparel industry. Fashion colloquia, São Paulo. (date of access: 05.11.2019)

Duarte AY, Sanches RA, Dedini FG. (2018). Assessment and technological forecasting in the textile industry: From first industrial revolution to the Industry 4.0. Strategic Design Research Journal. 2018 Jul 30;11(3):193-202. (date of access: 05.11.2019)

Ena O, Mikova N, Saritas O, Sokolova A. (2016). A methodology for technology trend monitoring: the case of semantic technologies. Scientometrics. 2016 Sep 1;108(3):1013-41. (date of access: 05.11.2019)

Foster, K. (2016). A prediction of US knit apparel demand: making the case for reshoring manufacturing investment in new technology. *Journal of Textile and Apparel, Technology and Management, 10* (2). (date of access: 05.11.2019)

Franco, M. A. (2017). Circular economy at the micro level: A dynamic view of incumbents' struggles and challenges in the textile industry. Journal of cleaner production, 168, 833-845. (date of access: 05.11.2019)

Gibson E, Daim T, Garces E, Dabic M. (2018). Technology foresight: A bibliometric analysis to identify leading and emerging methods. Foresight. 2018;12(1 (eng)). (date of access: 05.11.2019)

Godet, M. (2001). Creating Futures: Scenario Planning as a Strategic Management Tool. London, Economica. 2001. (date of access: 05.11.2019)

González-Sanmamed M, Muñoz-Carril PC, Santos-Caamaño FJ. (2019). Key components of learning ecologies: A Delphi assessment. British Journal of Educational Technology. 2019. (date of access: 05.11.2019)

Gornostaeva, G., & Barnes, D. (2015) Offshoring and Backshoring in the British Fashion and Apparel Industry: a Literature Review. In 20th International Symposium on Logistics: Reflections on Supply Chain Research and Practice. Centre for Concurrent Enterprise. (date of access: 05.11.2019)

Heinemann T. (2018). Digitalisation in the textile, apparel and footwear industry – a threat to industrializing and developing market economies? KfW Research Focus on Economics No. 214, 9 July 2018. URL: https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Fokus-Volkswirtschaft/Fokus-englische-

Dateien/Fokus-2018-EN/Fokus-Nr.-214-July-2018-Digitalisation-Textile-Industry_EN.pdf (date of access: 05.11.2019)

Irun B. (2017). Business Opportunities and Challenges in The Textile and Apparel Market in China. [Electronic resource] URL: http://ccilc.pt/wp-content/uploads/2017/07/eu_sme_centre_report_tamarket_in_china_2017.pdf (date of access: 05.11.2019)

Keenan, M., Saritas, O., & Kroener, I. (2004). A dying industry–or not? The future of the European textiles and clothing industry. *foresight*, *6*(5), 313-322. (date of access: 02.11.2019)

Keller C., Magnus K., Hedrich S., Nava P., Tochtermann T. (2014) Succeeding in tomorrow's global fashion market// McKinsey. URL: https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/succeeding-in-tomorrows-global-fashion-market (date of access: 08.11.2019)

Kim, E., & Johnson, K. K. (2009). Forecasting the US fashion industry with industry professionals–part 1: Materials and design. *Journal of Fashion Marketing and Management: An International Journal*, *13*(2), 256-267. (date of access: 05.11.2019)

Kim, E., & Johnson, K. K. (2009). Forecasting the US fashion industry with industry professionals–part 2: Production and retailing. *Journal of Fashion Marketing and Management: An International Journal*, *13*(2), 268-278. (date of access: 01.11.2019)

Kim, H. Y., Jolly, L., & Kim, Y. K. (2007). Future forces transforming apparel retailing in the United States: An environmental scanning approach. *Clothing and Textiles Research Journal*, *25*(4), 307-322. (date of access: 01.11.2019)

Kirchain, R., Olivetti, E., Miller, T. R., & Greene, S. (2015). Sustainable apparel materials. Materials Systems Laboratory, Massachusetts Institute of Technology, Cambridge. (date of access: 05.11.2019)

Kistamah, N., Hes, L., & Rajmun, K. (2017). Physical properties of nonwoven and woven felted fabrics. Research Journal of Textile and Apparel, 21(3), 178-187. (date of access: 05.11.2019)

Köhler, A. R. (2013). Anticipatory Eco-Design Strategies for Smart Textiles: Perspectives on environmental risk prevention in the development of an emerging technology. (date of access: 05.11.2019)

LEAD (2018). 30 trends for the textile industry. URL: https://www.lead-innovation.com/english-blog/how-digitisation-affects-the-textile-industry (date of access: 05.11.2019)

Lu, J. (2015). Forecasting of US Total Textiles and Apparel Export to the World in Next 10 Years (2015-2025). *Journal of Textile and Apparel, Technology and Management*, *9*(2). (date of access: 05.11.2019)

McCarthy, B. J. (2016). An overview of the technical textiles sector. In Handbook of technical textiles (pp. 1-20). Woodhead Publishing. (date of access: 05.11.2019)

McEleny (2017). Behind Alibaba's mission to reduce counterfeit goods using big data and technology. [Electronic resource] URL: https://www.thedrum.com/news/2017/06/19/behind-alibaba-s-mission-reduce-counterfeit-goods-using-big-data-and-technology (date of access: 05.11.2019)

Mendonça, S., e Cunha, M. P., Kaivo-oja, J., & Ruff, F. (2004). Wild cards, weak signals and organisational improvisation. *Futures*, *36*(2), 201-218. (date of access: 05.11.2019)

Meissner D., Gokhberg L., Saritas O. (Ed.) (2019). Springer, 2019. Emerging Technologies for Economic Development. Ed. by D. Meissner, L. Gokhberg, O. Saritas. Springer, 2019. (date of access: 05.11.2019)

Milshina Y., Vishnevskiy K. (2019). Roadmapping in fast changing environments – the case of the Russian media industry // Journal of Engineering and Technology Management. 2019. Vol. 52. P. 32-47. (date of access: 05.11.2019)

Morlet A., Opsomer R., Herrmann S., Balmond L., Gillet C., Fuchs L. (2017). A new Textiles Economy: Redesigning Fashion's Future// Ellen MacArthur Foundation. URL: https://www.ellenmacarthurfoundation.org/assets/downloads/A-New-Textiles-Economy.pdf (date of access: 05.11.2019)

Nayak, L., & Mishra, S. P. (2016). Prospect of bamboo as a renewable textile fiber, historical overview, labeling, controversies and regulation. Fashion and Textiles, 3(1), 2. (date of access: 05.11.2019)

Nazarko, Ł. (2017). Future-Oriented Technology Assessment. *Procedia Engineering*, *182*, 504-509. (date of access: 05.11.2019)

OECD (2018). OECD Due Diligence Guidance for Responsible Supply Chains in the Garment and Footwear Sector. [Electronic resource] URL: https://www.oecd-ilibrary.org/governance/oecd-due-diligence-guidance-for-responsible-supply-chains-in-the-garment-and-footwear-sector_9789264290587-en (date of access: 01.11.2019)

Okur N, Saricam C. (2019). The Impact of Knowledge on Consumer Behaviour Towards Sustainable Apparel Consumption. InConsumer Behaviour and Sustainable Fashion Consumption 2019 (pp. 69-96). Springer, Singapore. (date of access: 02.11.2019)

Oxborrow, L. (2015). Future scenarios in UK apparel supply chains: a disaggregative Delphi study (Doctoral dissertation, Nottingham Trent University). (date of access: 02.11.2019)

Pal, R., & Sandberg, E. (2017). Sustainable value creation through new industrial supply chains in apparel and fashion. In IOP Conference Series: Materials Science and Engineering (Vol. 254, No. 20, p. 202007). IOP Publishing. (date of access: 05.11.2019)

Pavlova, D., Milshina, Y., Vishnevskiy, K., & Saritas, O. (2018). The Role Of Wild Cards Analysis In Foresight Studies: The Case Of Russia. Higher School of Economics Research Paper No. WP BRP, 89.

Popper, R. (2008). How are foresight methods selected? F*oresight*, *10*(6), 62-89. (date of access: 05.11.2019)

Rosenberg D, Grafton A. (2013). Cartographies of time: A history of the timeline. Princeton Architectural Press; 2013 Jul 2. (date of access: 05.11.2019)

Saricam, C., Kalaoğlu, F., Polat, S., & Cassill, N. L. (2013). Application of Godet's Scenario Methodology to the Turkish Apparel Industry. Fibres & Textiles in Eastern Europe. (date of access: 05.11.2019)

Saricam, C., Polat, S., Cassill, N. L., & Kalaoğlu, F. (2014). Strategy Development and Assessment via Scenarios for the Turkish Apparel Industry. Fibres & Textiles in Eastern Europe. (date of access: 05.11.2019)

Saricam C, Okur N. (2019). Analysing the Consumer Behavior Regarding Sustainable Fashion Using Theory of Planned Behavior. InConsumer Behaviour and Sustainable Fashion Consumption 2019 (pp. 1-37). Springer, Singapore. (date of access: 01.11.2019)

Saritas, O., & Smith, J. E. (2011). The big picture–trends, drivers, wild cards, discontinuities and weak signals. Futures, 43(3), 292-312. (date of access: 05.11.2019)

Saritas O, Proskuryakova L. (2017). Water resources–an analysis of trends, weak signals and wild cards with implications for Russia. foresight. 2017 Apr 10;19(2):152-73. (date of access: 04.11.2019)

Saxena, A., & Khare, A. K. (2015). Development of green manufacturing system in Indian apparel industry. In Systems Thinking Approach for Social Problems (pp. 375-384). Springer, New Delhi. (date of access: 05.11.2019)

Simonse, L. W., Hultink, E. J., & Buijs, J. A. (2015). Innovation roadmapping: Building concepts from practitioners' insights. *Journal of Product Innovation Management*, *32*(6), 904-924. (date of access: 05.11.2019)

Skulimowski AM. (2016). The Role of Creativity in the Development of Future Intelligent Decision Technologies. InKnowledge, Information and Creativity Support Systems: Recent Trends, Advances and Solutions. 2016. (pp. 279-297). Springer, Cham. (date of access: 04.11.2019)

Sohn, A. P. L., Vieira, F. D., Filho, N. C., Cunha, I. J., & Zarelli, P. R. (2016). Knowledge Transmission in Industrial Clusters: Evidence from EuroClusTex. European Planning Studies, 24(3), 511-529. (date of access: 05.11.2019)

Strategy for waste recycling industry in the Russian Federation up to 2030. (2018). [Electronic resource] URL: http://government.ru/docs/31184/ (date of access: 05.11.2019)

S&T Long-Term Foresight of the Development of Russian Federation 2030 (2013). [Electronic Resource] URL: http://static.government.ru/media/files/41d4b737638b91da2184.pdf (date of access: 05.11.2019)

Tian X, Geng Y, Zhong S, Wilson J, Gao C, Chen W, Yu Z, Hao H. (2018). A bibliometric analysis on trends and characters of carbon emissions from transport sector. Transportation Research Part D: Transport and Environment. 2018 Mar 1;59:1-0. (date of access: 02.11.2019)

Tsai WH. (2018). Green production planning and control for the textile industry by using mathematical programming and industry 4.0 techniques. Energies. 2018 Aug;11(8):2072. (date of access: 05.11.2019)

Vishnevskiy K., Meissner D., Egorova O. (2015). Foresight for SMEs: How to Overcome the Limitations in Small Firms? / NRU Higher School of Economics. Series WP BRP "Science, Technology and Innovation". 2015. No. 45/STI/2015. (date of access: 05.11.2019)

Vishnevskiy K, Calof J, Meissner D. (2019). Corporate foresight and roadmapping for innovation in Russia: A joint university corporate experience. InFutures Thinking and Organizational Policy 2019 (pp. 157-176). Palgrave Macmillan, Cham. (date of access: 05.11.2019)

WTiN (2018). Digital Transformation Outlook. Global textile and apparel value chain survey 2018. URL: https://www.wtin.com/media/mags/Reports/DigitalTransformationSurvey2018/11418171219/offline/download.pdf (date of access: 05.11.2019)

Zeidler, H., Klemm, D., Böttger-Hiller, F., Fritsch, S., Le Guen, M. J., & Singamneni, S. (2018). 3D printing of biodegradable parts using renewable biobased materials. Procedia Manufacturing, 21, 117-124. (date of access: 03.11.2019)

Appendix A

Description of existing methodological approaches of future studies in the textile and apparel industry

Title	Study	Time Horizon of the study	Scope of the research	Aim	Results	Methodology	Methods used	Completeness of the methodology description	Advantages of methodology	Disadvantages of methodology
"Alpha", "Beta", "Delta" outlooks	A dying industry – or not? The future of the European textiles and clothing industry (Keenan et al., 2004)	2015	European market	To explore possible scenarios ("outlooks") of clothing and textiles industry future development	Three outlooks for five key drivers of the industry	Identification of five central "drivers" that lie behind the visible and/or anticipated trends and developments in the sector: • international trade relations; • organization and structure of the industry; • new and emerging technologies; • human resources; • enforcing international rules and conventions. Each driver is presented in a common framework, involving a brief explanation of the salience of the issue, and an account of the major features it involves; and presentation of three "outlooks". The outlooks represent three distinctive patterns of development along the following lines: • Alpha outlooks represent a "business as usual" future, in effect, an extrapolation of current forces and processes • Beta outlooks consider, in particular, some of the many things that could "go wrong". Delta outlooks consider potential changes in direction. The aim is to go beyond analysis in terms simply of success or failure of the plans and programmed mentioned above.	• Literature review; • Extrapolation; • Stakeholder analysis; • Critical technologies; • Survey; • Backcasting; Scenario writing.	• Partially described	• 3 well-described scenarios for five key drivers of future textile and apparel development •	• The research concerns only European market of textile and clothing • Missing conclusion and further recommendation to use it. • Lack of the methods and methodology explanation used during the research.
Environmental scanning (Stoffel's model)	Future Forces Transforming Apparel Retailing in the United States An Environmental Scanning Approach (Kim et al., 2007)	-	US market	To identify environmental change factors that may influence the future of the apparel retailing	Numerous issues and trends in social, economic, competitive, technological and political spheres (scanning outcomes)	Paper identified environmental change factors that may affect the future of apparel retailing. Based on a synthesis of results that have been gathered over the course of the environmental scanning period, author aimed at facilitating the understanding of potential trends and directions for the future and providing insights into formulating effective strategies for apparel retailing in the United States. There are three main action elements of the scanning process: (a) gathering inputs and generating information, (b) synthesizing and evaluating emerging issues,	• Literature review; • Extrapolation; • Scanning; • Interview; • Cross impact/analysis; • Stakeholder analysis; • Survey.	•	• Authors attempted to scan a vast array of information sources. • In addition to published materials (e.g., newspaper articles, journals, magazines,	• Limited number of methods used. • Narrow focus of the research (only US textile and apparel industry). •

						and (c) extracting key future forces and producing an in-depth report.			books), they referred to conferences, CEO lectures, and informal discussions with retail experts (e.g., managers, researchers).	
Exploratory scenarios	An approach to scenario analysis of the sustainability of an industrial sector applied to clothing and textiles in the UK (Allwood et al., 2008)		UK market	To examine the future sustainability of clothing and textiles sector	Scenarios, the ideal customer characteristics, threats and opportunities	Methodology is aimed to map the sector, identify an influences diagram, create scenarios based on case study products (knitted cotton T-shirt; woven viscose blouse; tufted polyamide carpet), analyze them using the 'triple bottom line graphic equalizer' and present draft analysis to stakeholders for feedback.	• Literature review; • Extrapolation; • Scanning; • Stakeholder analysis; • Interview; • Quantitative Scenarios; • Expert panel; • Survey; • Backcasting; • Scenario writing; • Simulation.		The draft report was circulated widely to stakeholders across the sector with a request for feedback. The feedback proved strongly valuable – in identifying results that were partial or misleading, and confirming or challenging the conclusions from the quantitative analysis.	• Scenarios based on case study products. • The 'triple bottom line' of sustainability includes only environmental, social, economic impacts. Limited number of parameters assessing effects (social: employment – number of workers; economic: GNI, balance of trade, operating surplus; environment: 1000 tonnes CO2 equivalent, waste in tonnes) • Although it is impossible to estimate how 'complete' this set of suggestions is, until time has passed
Survey, interview	Forecasting the US	2020-2030	US market	To investigat	Expert judgements	The study design was based on a qualitative approach.	• Interview; • Expert panel;		Participants were asked not	• Lack of foresight

	fashion industry with industry professionals (Kim & Johnson, 2009)			e the future of fashion industry	of 62 professionals on the future of fiber and fabrics, apparel production, apparel design, production and retailing	A questionnaire was distributed to 287 professionals in the US fashion industry either in person or via e-mail. Participants were recruited at a symposium, at a seminar for industry professionals, through a membership list of a professional association as well as through directories of apparel store managers and manufacturers.	• Survey.		only to make predictions but also to justify their predictions however, not all of the participants provided justifications.	methods used for the research (only qualitative approach). • Limited focus of the research (only US textile and apparel industry).
Godet's scenario planning	Application of Godet's Scenario Methodology to the Turkish Apparel Industry (Saricam et al., 2013)	2025-2030	Turkish market	To develop scenarios of Turkish apparel industry development	Four future scenarios of Turkish apparel industry development	The Godet's scenario method comprises two stages: "the construction of a database" and "the setting out of scenarios leading to the generation of forecasts": • In the first stage of base construction, a detailed image of the present state of the system, which has economical, technological, political and sociological aspects, is drawn by identifying firstly all the variables and relationships between them. Then the leading actors and their decision mechanisms are defined and analyzed with the MACTOR method suggested. • In the second stage, many possible hypotheses are developed and a selection is made on the basis of the likelihood that they may occur. In Godet's approach, a kind of cross impact analysis called SMIC is used at this step, which allows to construct a hierarchy among the scenarios based on their probabilities. The working procedure involved four stages of interviews held with experts matching the requirements of the method. The results were checked for further corrections to be made at each step. In the end, four scenarios were derived from six hypotheses with greater probabilities verified by cross checking with results from a larger population.	• Literature review; • Interview; • Cross impact analysis.	•	• Well-balanced approach to use experts' opinions for building the structural matrix involving variables that could affect the textile and apparel industry and their impact on each other. • The MICMAC method, a system of multiplication of matrices, was applied to classify the variables according to the influence they had.	• There is no specific technique of the selection of experts. • Scenarios were done only for a national industry. The European perspective was taken into consideration as an outer environment indicator. • There is no explanation how authors measured the probabilities of scenarios.
Technology assessment	Anticipatory Eco-Design Strategies for Smart Textiles Perspectives on environmental risk	2023		To promote environmentally conscious design of smart textiles for the	The score of smart textiles impact on population size, affluence and technology	Technology assessment (TA) was the general methodological framework of this research. It generates forward-looking knowledge about possible future effects of a technology as a means of scientific policy advice. the focus of the research was on the identification of possible environmental risks of smart textiles and the options to prevent such risks during the innovation process.	• Literature review; • Extrapolation; • Interview; • Stakeholder analysis; • Critical technologies; • Expert panel;	•	• An interactive research approach was chosen in an endeavour to establish a bi-directional risk communicatio	The general mode of research was limited by qualitative exploratory research. •

	prevention in the development of an emerging technology (Köhler, 2013)			prevention of adverse environmental impacts	efficiency		• Survey.		n and consultation with the stakeholders. • The means of communication included peer-reviewed academic journals, conference presentations, workshops and focus-group discussions as well as online dissemination of research findings	
MICMAC, MACTOR, SMIC	Strategy Development and Assessment via Scenarios for the Turkish Apparel Industry (Saricam et al., 2014)	2025-2030	Turkish market	To establish strategies for the Turkish apparel industry development	Thirty seven strategies for the Turkish apparel industry development	First part: Godet's scenario planning method • First Step: Delimitation of the system • Second Step: Identification of key variables - MICMAC (cross impact matrix-multiplication applied to classification) • Third Step: Retrospective and actors' strategies – MACTOR (matrix of alliances and conflicts: tactics, objectives and recommendations) • Fourth Step: Building scenarios – SMIC (French acronym for cross impact systems and matrices) Second part: Developing and accessing strategies • First Step: Brainstorming with experts Second Step: Identification of key strategies – MICMAC	• Literature review; • Interview; • Cross impact analysis; • Stakeholder analysis; • Expert panel; • Scenario writing.	•	• The working procedure involved four steps of interviews in accordance with the requirements of the method. The results were checked at each step for further corrections to be made. • Moreover the experts' opinions were subjected to control with inter rater agreement and the opinions of each expert were checked to see their discriminative power of the expert.	• There is no specific technique of the selection of experts. • Scenarios were done only for a national industry. The European perspective was taken into consideration as an outer environment indicator.

Disaggregative Delphi survey	Future scenarios in UK apparel supply chains: a disaggregative Delphi study (Oxborrow, 2015)	2020	UK market	To discover the issues of apparel supply chains in the UK and build future scenarios for their development	Three future scenarios of supply chains development	Disaggregative Delphi study is based on interviews with experts from across the UK apparel supply chain, a survey ranking variables as important now and in 5 years' time and development of three future scenarios from which emerging supply chain configurations are presented.	• Literature review; • Extrapolation; • Scanning; • Interview; • Quantitative Scenarios; • Expert panel; • Delphi; • Scenario writing.		Representative participation from across the retail and supply complex enhances validity and points to opportunities to test emergent theory	• The Delphi process is questioned for its limited generalisability (Okoli and Pawlowski, 2004) and the purpose of this research has been to explore the emerging supply chain practices in the apparel market, specifically. • Research was done only for a national industry (UK).
ARIMA analysis (Box-Jenkins), regression analysis	Forecasting of US Total Textiles and Apparel Export to the World in Next 10 Years (2015-2025) (Lu, 2015)	2025	US market	To forecast the U.S. total textiles and apparel export	Statistical data on future the U.S. total textiles and apparel export	ARIMA model is complex a linear model, which create explanatory variables from the original demand history by using autocorrelations to identify those lagged demand historical values that best predict future demand. There are three parts of the ARIMA model: Autoregressive (AR), Integrative (I), Moving average (MA).	• Extrapolation; • Cross impact analysis.		The ARIMA model was calibrated using the author's expectations. By modeling the past behavior of US textile and apparel exports using historical data, the author adjusted the coefficients of the parameter by taking into account the trends and the future expectations.	• Only technical forecasting based on previous data. • There are a lot of factors that were not taking into consideration (dollar exchange rate etc.).
ARIMA analysis (Box-Jenkins)	A prediction of US knit apparel demand: making the case for reshoring manufacturing investment in new technology	2035	US market	To demonstrate the prospective growth of knit apparel market	Statistical data on future knit apparel demand	The time-series analysis method chosen for this study is univariate Box-Jenkins, or ARIMA analysis. This type of forecasting allows for a combination or integrated (I) of time series and regression methods (AR, MA) and is appropriate given the historical data. ARIMA model requires two steps: first, to analyze the data series, and second, to choose the best fit forecast	• Extrapolation; • Cross impact analysis.		The benefit to using ARIMA over other modeling methods is the ability to create explanatory variables and identify the lagged demand historical values,	• Only technical forecasting based on previous data. • There are a lot of factors that were not taking into consideration (dollar exchange rate

	(Foster, 2016)								aiding in projections.	etc.).
Literature review, consultation workshops, interviews	Apparel manufacturing 4.0: a perspective for the future of the Brazilian textile and apparel industry (Da Silveira Bruno & Pimentel, 2016)	2030	Brazilian market	To combine the main disruptive technologies within four strategic emphases of apparel industry	A list of ten disruptive technologies	Research project implied creation of the organizational architecture responsible for the production, analysis and redirection of prospective studies that precedes the presentation of the final conclusions. ABIT, ABDI and SENAI CETIQT were the institutions that constituted the Management and Knowledge Production Nucleus, responsible for involving 150 people, thus composing the Greater Committee for the Brazilian Textile and Apparel Industry (CSITCB), the body responsible for specifying the study's emphases.	• Literature review; • Scanning; • Interview; • Expert panel; • Survey.	•	• In an eighteen-month period, the CSITCB had three meetings; studies of decision support were undertaken between meetings with the participation of committee members.	• Unclear methodology. • Possible shift in opinions • Limited focus of the research (only Brazilian textile and apparel industry).
Expert workshops, Industrial Landscape Vision 2025 (ILV_{2025})	Textiles and Clothing Manufacturing: Vision for 2025 and Actions Needed (Bontoux et al., 2017)	2025	EU market	To identify the long-term needs, opportunities and challenges in textiles and clothing manufacturing	The vision statement, four clusters of challenges, suggestions for policy actions	Authors developed a five-step process that takes a maximum of 6 months to implement, including two expert workshops. • Step 1 is to select a sector of interest. • Step 2 is dedicated to engaging with the selected sector and its stakeholders and recruiting study participants. • Step 3 is to identify the key drivers of change for this • sector and to create a long-term (10-15 years) vision for it. • In Step 4, the main challenges and opportunities faced in achieving this vision are identified. Finally, in Step 5, participants develop the most desirable responses to these challenges from both the industry perspective and the policy perspective.	• Literature review; • Scanning; • Interview; • Stakeholder analysis; • Expert panel; • Scenario writing.	•	• The project used Industrial Landscape Vision 2025 (ILV2025) as a tool to develop a method for working with European manufacturing sectors to understand the long-term needs and challenges faced, to develop a vision for identifying key opportunities and challenges, and to develop potential responses through engagement with a range	The method and tool need the further research for additional refinement and possible combination with quantitative approaches.

									of stakeholders. The method was designed to work with case studies of various European manufacturing sectors. • ILV2025 used STEEP-classification for trends. • There were the analysis of challenges and opportunities as well as policy develop the most desirable responses to address these effects.	
Literature review, analysis of statistical data	Business Opportunities and Challenges in The Textile and Apparel Market in China (Irun B., 2017)	2025	Chinese market	To give an overview of textile and apparel market in China for European SME	Market analysis, future challenges and opportunities	The report is based on the analysis of the statistical data (China National Bureau of Statistics, China Chamber of Commerce for import and export of Textile and Apparel etc.)	• Literature review; • Scanning; • Stakeholder analysis; • SWOT; • Survey.	There is no description of the methodology of the research	It is a consulting report, but maybe useful from the perspective of indentification of global and Chinese industry trends.	There is no description of the methodology of the research

Appendix B

Detailed description of the global trends in the textile and apparel industry (fragment)

Trend	Description	Capacities/Opportunities for Russia	Stakeholders
Growth of circular economy and recycling intensification	Apparel and textiles manufacturing, be one of the most polluting industries for the environment, is being reoriented towards less usage of natural resources and more intensive recycling.	• Reduction of anthropogenic pressure on the environment • Promotion of circular economy • Replacement of natural resources by new artificial materials • Improvement of deep recycling technologies • Extension of apparel and textiles product life cycles	• Large corporations, state agencies, non-profit organizations
Development of small-scale manufacturing and its localization	Apparel and textiles manufacturing is being removed from Asia-Pacific countries to local regions of products consumption due to robotization, which eliminates the advantage of low labor costs.	• Increasing the shipments of industrial robots • Wide application of industrial robots in textiles industry • Prevention of human error • Quick response to consumers behavior changes • Reduction of logistics costs	• Fashion brands, large tech companies, SMEs
Rise in demand for customized and personalized products	There is an increase in global demand for personalized apparel design that now can be easily achieved by means of digital platforms and online retail channels.	• Increasing the share of personalized products • Reduction of the transaction costs of deals • Improvement of the channels of communication • Diversification of personalization tools • Attraction of new customers	• Tech start-ups, SMEs, fashion brands
Digitalization and robotization of manufacturing processes	Traditional models of textiles manufacturing are being significantly improved and complemented by digital technologies (Industrial Internet of Things, AI, cloud computing etc.).	• Acceleration of manufacturing speed • Optimization of manufacturing processes • Predictive maintenance of equipment • Increasing the transparency of manufacturing • Real-time communication with customers and suppliers	• Large corporations, tech start-ups, state agencies
Rise in demand for new competencies and professions	Global transformation of the textile and apparel industry require additional employee training in the sphere of advanced production management and new materials application.	• Increasing the effectiveness of robotization and digitalization • Promotion of human-robot collaboration • Mass adoption of new materials • Improvement of educational programs	• Large corporations, SMEs, state agencies

Appendix C

Results of expert interviews: verification of global trends, assessment of periods of their development, their impact on national textile and apparel industry (closed question format, distribution of answers) and relevant future events (open question format)

Area	Trend	Time period			Opportunities					Threats					Relevant future event
					Evaluation of influence (1-low, 5 – high)					Evaluation of influence (1-low, 5 – high)					
		2017-2020	2021 – 2025	2026 – 2030	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	
Social	Digitalization of consumer experience	8	2	0	0	5	2	2	1	3	6	1	0	0	Up to 35% of fashion customers rely on recommendations from social networks and use other digital platforms to get information on trends, exchange experiences, or compare prices.
	Emergence of new competencies and professions	2	7	1	0	1	7	1	1	8	2	0	0	0	40% of online clothing orders are returned due to imperfect sizing and fit. By 2023, 'digital tailor' will become a common profession.
	Urbanization and growth of the middle class	0	3	7	0	9	1	0	0	2	6	1	1	0	In the last 15 years, clothing production has almost doubled due to a growing middle-class population worldwide. By 2030, the global middle class is expected to increase by 2 billion people and reach 5.3 billion people.
Technological	Improved business intelligence and data analytics	1	9	0	0	7	2	1	0	4	6	0	0	0	More than 30% of manufacturers of fibre, textile and apparel, brands and retailers are planning to invest in connected devices, data analytics, connected ERP/MES/PLM systems and smart sensors in 2018-2023
	Development of nonwoven fabrics	3	7	0	1	3	6	0	0	9	1	0	0	0	The global market size of nonwoven fabrics is estimated to achieve nearly 35 billion dollars in 2022 (2016 - 22.6 billiion dollars)

	Digitalization and robotization of manufacturing	4	6	0	0	0	2	8	0	1	7	2	0	0	96% of equipment manufacturers and 85% of manufacturers of fibre, textile and apparel are aiming to achieve a digital transformation strategy in 2018-2023
	Introduction of radically new technologies and materials	0	1	9	0	0	6	2	2	9	1	0	0	0	The global market size of smart factories is expected to reach 275 billion dollars in 2026 (2018 - 135 billion dollars).
Economic	Increased demand for customized and personalized products	3	7	0	2	7	1	0	0	4	6	0	0	0	Nearly 70% of apparel producers think that consumers expect customized apparel and footwear options. More than 30% of apparel industry change-makers will be moving towards personalized apparel within 5 years.
	Wide spread of smart textiles	1	6	3	0	5	4	1	0	9	1	0	0	0	The global market size of smart textiles is projected to reach almost 6 billion dollars in 2025 (CAGR - 30% in 2018-2025)
	Growth of technical textile production	1	2	7	2	8	0	0	0	9	1	0	0	0	The global market size of technical textile is projected to reach 250 billion dollars by 2026 (2018 - 175 billion dollars)
Environmental	Strengthening of environmental safety standards	6	3	1	2	2	6	0	0	3	7	0	0	0	The standards that examine the use of chemicals in textile production: Bluesign (assesses all input streams, including raw materials and chemicals), Oeko-Tex Eco Passport (specific guidelines - MRSL and RSL, REACH and ZDHC), GreenScreen and Cradle to Cradle (require assessment and full disclosure of the materials used in a product)
	Reduction of usage of non-renewable resources	0	8	2	4	5	1	0	0	7	0	3	0	0	The world's third largest apparel company - Zara - commited to start making clothes from 100% sustainbale fabrics, use renewable energy sources and produce zero

															landfill waste by 2025
	Growth of circular economy and recycling intensification	1	4	6	3	3	4	0	0	8	2	0	0	0	The overall benefit to the world economy will reach 192 billion dollars in 2030 if the principles of circular economy are implemented into the textile and apparel industry
Political	Innovation-driven green targets	6	3	1	2	2	6	0	0	9	1	0	0	0	The China's 13th five-year plan for its textile and apparel industry includes such development goals as reduced energy use, CO2 intensity and water use per value-added as well as re-use of textile fiber, R&D spending and number of patents
	Fostering collaboration among manufacturers and innovative clusters development	2	8	0	4	1	5	0	0	10	0	0	0	0	By 2025 the textiles and clothing industry, including fibre-based materials, clothing, home and technical textiles, will be a strategic EU industry sector based on advanced manufacturing techniques, cross-sectorial collaborations and strategic clusters

Appendix D

Results of expert interviews: opportunities and threats for Russian manufacturers, brands and retailers (closed question format)

Area	Trend	Opportunities for Russian manufacturers, brands and retailers					Threats for Russian manufacturers, brands and retailers				
		Business model innovation	Product diversification	Productivity growth	Quality improvement	Costs reduction	Strong global competition	Increased costs	Safety hazard	Technological complexity	Lack of skills and competencies
Social	Digitalization of consumer experience	+			+		+			+	
	Emergence of new competencies and professions	+	+		+						
	Urbanization and growth of the middle class	+	+						+		+
Technological	Improved business intelligence and data analytics	+		+			+			+	
	Development of nonwoven fabrics		+			+				+	
	Introduction of radically new technologies and materials		+	+	+				+		
Economic	Increased demand for customized and personalized products	+	+				+			+	
	Wide spread of smart textiles	+	+							+	
	Growth of technical textile	+	+							+	

	production										
Environmental	Strengthening of environmental safety standards	+	+		+			+			+
	Reduction of usage of non-renewable resources	+			+			+			
	Growth of circular economy and recycling intensification	+		+	+			+			
Political	Innovation-driven green targets	+	+		+			+			
	Fostering collaboration among manufacturers and innovative clusters development	+		+		+					+

Appendix E

Results of expert interviews: verification of wild cards, assessment of periods and probability of their possible realization (closed question format, distribution of answers)

Area	Trend	Relevant wild card	Probability of a wild card realization			Time horizon of potential wild card realization		
			High	Medium	Low	2017-2020	2021-2025	2026-2030
Social	Digitalization of consumer experience	VR shopping	6	1	3	1	3	6
	Emergence of new competencies and professions	Disappearance of the weaver profession	4	6	0	0	7	3
Technological	Improved business intelligence and data analytics	Fully automated management of textile and apparel manufacturing	2	3	5	0	2	8
	Development of nonwoven fabrics	Fruit fiber	1	4	5	8	2	0
		Bioengineered clothes	3	7	0	0	3	7
	Introduction of radically new technologies and materials	Superflex powered clothing	6	2	2	3	4	3
		Color-changing fabric	1	8	1	6	3	1
		Spray-on clothing	7	2	1	7	2	1
Economic	Increased demand for customized and personalized products	Shape-shifting apparel	3	6	1	0	2	8
	Wide spread of smart textiles	Smart clothes for cooling/heating	8	2	0	1	7	2
		Self-healing textile	1	2	7	0	4	6
	Development of small-scale manufacturing and its localization	3D-printing manufacturing of textile and clothes	6	3	1	5	3	2
	Reduction of usage of non-renewable resources	Prohibition of use of non-renewable resources	0	3	7	0	1	9

Authors:

Yulia V. Milshina
National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Senior Research Fellow
E-mail: ymilshina@hse.ru

Daria A. Pavlova
National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Research assistant
E-mail: dpavlova@hse.ru

Konstantin O. Vishnevskiy
National Research University Higher School of Economics. Institute for Statistical Studies and Economics of Knowledge. Head of unit for digital economy studies
E-mail: kvishnevskiy@hse.ru