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Wearable technologies in the fashion value ecosystem: a conceptual model

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Abstract

Purpose – The fashion sector is complex. It involves multiple actors with distinct and potentially conflicting interests, forming a value ecosystem. Thus, knowing the interested parties and belonging to the fashion sector may be a means to promote technological innovation, such as products with wearables. The purpose of this paper to identify the participants of the fashion ecosystem from the perspective of wearable technologies and develop a conceptual model.

Design/methodology/approach – The present work aims to identify the participants (actors) and develop a conceptual model of the fashion ecosystem from the perspective of wearable technologies. The systematic literature review is the recommended method to qualitatively analyze documents and identify the interested parties (actors) in the fashion sector in order to design the proposed conceptual model.

Findings – From the studies, the conceptual model of the fashion value ecosystem was designed, and the wearable product was considered its core business. The studies identified addressed ecosystems of fashion value in general but not specific to wearable products and their relations with other complementary industries.

Research limitations/implications – The model was designed using secondary data only. Its validation is relevant through interviews with experts.

Originality/value – In terms of relevance, when conducting a systematic literature review, there were no studies that included wearable technologies in the fashion ecosystems discussed and their relations with other industries. The topic of wearables is an emerging subject that needs further research aiming to insert this technology in productive sectors.

Keywords Fashion sector, Fashion ecosystem, Wearable technologies, Systematic literature review

Paper type Research paper

1. Introduction

Making products with a short life cycle (Abecassis-Moedas, 2006) is a characteristic of the fashion sector (Boscacci, 2018). Therefore, the need to innovate, produce and sell items is

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continuous (Tervilä, 2015), and the synergies to support the growth and development of the sector are essential (European Commission, 2019).

As an economic sector, fashion employs 75 million people worldwide, and its market value is estimated at 1.7 trillion dollars (Tervilä, 2015). The fashion industry's value surpasses 3.0 trillion dollars (16 trillion Brazilian reais on June 29, 2020), representing 2% of the world GDP (Fashion United, 2020). In the Brazilian market, fashion is an industrial sector with the positive job and income multipliers (Serrano, Rodrigues, Lacerda, & Paraboni, 2018). The direct jobs generated in the textile and clothing sector total 1.5 million distributed in 25,000 formal companies, and other 8 million indirect jobs with income effects (Associação Brasileira da Indústria Têxtil e de Confecção – ABIT, 2020).

However, the fashion sector is complex (Jia, Yin, Chen, & Chen, 2020; Jin, 2004), since it involves multiple actors with distinct and potentially conflicting interests that need to be articulated to generate a co-evolution process (Moore, 1996). Ecosystem participants are interconnected and depend on each other to survive (Iansiti & Levien, 2004), creating value for products. Mapping the fashion sector (textiles and clothing) as an ecosystem is interesting as it enables developing joint actions with all actors (Staicu & Pop, 2018). Thus, knowing the interested parties belonging to the fashion sector may be a means to promote technological innovation, stimulate demand and measure the impacts generated by this sector (European Apparel and Textile Organisation – EURATEX, 2017), which shows ever-increasing competitiveness.

As pointed out by EURATEX (2004), the fashion sector is formed by several subsectors. Therefore, it is crucial to define which of them will be the object of this study since it aims to map the fashion value ecosystem from the perspective of wearable products. Wearable products have as functionality the user's interaction with the environment (Wood, 2018; Zhang, Stankovski, Saeed, Saeed, & Zhang, 2020) by placing the technology around the body employing sensors (O'Nascimento, 2020).

Wearable devices have achieved fast growth in the electronics market, providing interested buyers with various products to satisfy their needs and desires (Mardonova & Choi, 2018). Besides allowing constant, convenient, continuous and portable access for users (Dehghani & Dangelico, 2018), wearable products seek to enhance reality by superimposing computer-generated images or audio clips over the real world and provide sensitivity to the outside context by informing the users about their environmental and personal status (Billinghurst & Starner, 1999).

Wearable devices can be found in different industrial sectors (Mardonova & Choi, 2018), for example, for medical assistance purposes aiming to collect data on patient health (Heintzman, 2016). In the universe of the fashion sector, devices are found in aesthetic accessories combined or not with garments (Cantanhede, Dias, Gammarano, & Arruda Filho, 2018; Lazaroiu, 2012). Their use aims to add value to a piece of clothing by inserting electronic components (Marini, 2016). It is estimated that the sales of smart clothing will increase from 2.9 million pieces in 2018 to 10.5 million by 2022 (Richter, 2018).

Patents issued for smart clothing are not a new category in the wearables market (Dehghani & Dangelico, 2018); for example, between the 1960s and the 1990s, efforts concentrated on developing the first clothing with a wearable concept (O'Nascimento, 2020; Wood, 2018). However, information about the presence of such technologies in the production process of the fashion sector is still limited, and uncertainties about the insertion of wearable technologies in the production process are frequent (Dehghani & Kim, 2019). Furthermore, the production flow of fashion is different from conventional processes (Han, Han, & Kim, 2014) in that it includes innovative features, such as the user interaction with the product. Technology, therefore, changes the way work is carried out in organizations (Eidenhammer, 2018).

In addition, the development of products with wearable technologies faces difficulties in market positioning, as there is interaction with more than one industrial sector (Wood, 2018). For example, there are relations between the fashion and the electronics sectors, which play complementary roles in the complex productive context. Therefore, a valuable ecosystem is formed capable of producing goods with innovative and technological resources resulting from the interaction of different actors. Therefore, in-depth studies that consider the relations between different actors are essential for the competitiveness of the fashion sector (Serrano, Morandi, Veit, Mansilha, & Lacerda, 2020).

The present work aims to develop a conceptual model of the fashion value ecosystem from the perspective of wearable technologies. The participants of the fashion value ecosystem were identified in previous studies, and the systematic literature review (Morandi & Camargo, 2015) was the working method. It is worthwhile noting that the studies addressed ecosystems of fashion value in general but not specifically to wearable products and their relations with other complementary industries. Based on these studies, a conceptual model of the fashion value ecosystem was developed about wearable products. In addition, the issue of sustainability was incorporated by analyzing the final destination of the garments.

This article is structured into five sections, Section 1 is the Introduction. Then, the theoretical framework, the methodology and the research results are presented in Sections 2–4, followed by the final discussions and considerations of the study in Section 5.

2. Theoretical framework

This theoretical framework initially addresses value ecosystems and their relations with the fashion sector, followed by the premises for the insertion of wearable technologies in the fashion sector.

2.1 Value ecosystems and their relations with the fashion sector

Ecology is a science that examines complex relations and interactions between members or species of particular communities and their relations with the environment (Mengi, 2017). When addressing this concept in an industrial sector, Moore (1996) considered companies as a network of interconnected organizations and individuals with the objective of generating a process of co-evolution. Thus, ecosystems are a living community of interacting organisms, requiring diversity to function (Oksanen *et al.*, 2018).

According to Salonoja (2013), the ecosystem is an important concept as it helps to understand the complex business environment since the ownership and roles of actors belonging to it are identified (Staicu & Pop, 2018). Furthermore, the set of actors, comprising organizations, products and processes, are analyzed as a part of a comprehensive, interdependent system (Aarikka-Stenroos & Ritala, 2017).

In the logic of business ecosystems, the health of an organization influences the success and survival of all other participants in the ecosystem (Iansiti & Levien, 2004). In industries formed by subsystems, such as fashion (Mengi, 2017), the network of relations and the subsequent dynamics represented by the different stakeholders are highly complex (Staicu & Pop, 2018). Therefore, the alignment of views and the mutual support of interested parties are crucial (Moore, 1996).

The concept of the ecosystem has several interpretations (Aarikka-Stenroos & Ritala, 2017) and structures. It can be composed of eight dimensions, as proposed by Moore (1996) and Serrano (2018); four layers (Baghbadorani & Harandi, 2012); or six categories (Fragidis, 2017). Thus, the object of the study (core business) and the complexity of the environment define the necessary structure of the ecosystem. In this study, the core business is defined by products developed using the concept of wearable technologies.

The name of the ecosystem may vary depending on the focus of the study and the complexity of the sector, such as *service ecosystems* (Fragidis, 2017), *business ecosystems* (Moore, 1996) or *value ecosystems* (Serrano, 2018). We opted for the term "fashion value ecosystem," which enables identifying professionals, textile manufacturers, wholesalers and retail buyers (Mengi, 2017) as necessary members to create value for the core business and seek its co-evolution.

Finally, in the complex fashion value ecosystem, in which competition is related to the development of products with different levels of technology (Serrano *et al.*, 2018), producing competitive products that satisfy the needs of consumers (Kawamura, 2005) without harming the environment (Fletcher & Grose, 2012) is a constant challenge. In this perspective, it is interesting to understand fashion as a *value ecosystem* that adds economic, social and environmental value as it evolves (Serrano *et al.*, 2018). The following section addresses the theoretical framework of products developed from the concept of wearable technologies.

2.2 Insertion of wearable technologies in the fashion sector

In the era of Industry 4.0 and the Internet of Things (IoT), connectivity between humans and machines grows increasingly (Fernández-Caramés & Fraga-Lamas, 2018; Zhang *et al.*, 2020). As a result, new information and intelligence are generated for the industry (Chen, 2019) and users. Connectivity devices include wearable technologies, which seek interactivity between the environment and the user, assisting in motor and cognitive activities without limiting movements (Donati, 2004). Besides, they are characterized as products controlled by the user, always on and accessible (Mann, 1997).

Wearable products are inserted in several industrial sectors (Mardonova & Choi, 2018) and services, like health, agriculture, manufacturing, home automation and public safety (Fernández-Caramés & Fraga-Lamas, 2018). Thus, the use of wearable technologies for monitoring the health of employees may become a valuable resource for companies (Lavallière, Burstein, Arezes, & Coughlin, 2016). For instance, sensors can detect signs of health, social well-being (Stoppa & Chiolerio, 2014) and personal productivity (Fernández-Caramés & Fraga-Lamas, 2018; O'Nascimento, 2020), providing biometric data on the preferences and lifestyles of each user (Heintzman, 2016).

Wearable products are at the boundary between the physical and the digital worlds, where communication with remote objects and servers enables advanced monitoring services (Fernández-Caramés & Fraga-Lamas, 2018). They may drastically change the way we live and do business (Dehghani & Kim, 2019). Wearable products have as premise not to attract attention during use, but to dress the body (Eidenhammer, 2018) and provide the user with real-time information and experiences (Fernández-Caramés & Fraga-Lamas, 2018).

However, due to the need to carry extra equipment to monitor the desired data, 40% of wearable product users tend to put the equipment aside (Lavallière *et al.*, 2016). Consequently, the initial premise of dressing the body is still not being fully met. Advances are needed for a better user experience with wearable products (Lavallière *et al.*, 2016), such as joining industries that previously worked separately. With different product development techniques and manufacturing practices, computing, electronics, clothing and textiles could work together to develop such technological products (Wood, 2018).

Therefore, technical uncertainties about the manufacture of wearable products are numerous, and changes in production processes are frequent (Dehghani & Kim, 2019). This is a result of the need to define the way of inserting wearable technologies in the production of garments: whether the garment or textile acts as a support for electronic sensors or computing devices, enabling data output; or having all devices integrated at the level of textile production, be it at the fiber, fabric manufacture or finishing stages (Wood, 2018). Thus, making clothing using the wearable concept is still an object of study (Eidenhammer, 2018).

The scholars and decision-makers need to determine which new forms of integration connect the various parts of the field as it continues to grow (Dehghani & Kim, 2019). First, new technologies arising from the miniaturization of components foster research opportunities, such as incorporating conductors into the fabric thread (Wood, 2018). Second, the functionality of devices and cost reduction of the leading technologies cause the wearable market to grow rapidly (Dehghani & Kim, 2019). This research adopts this perspective, as it proposes to identify the necessary actors for the development of a product with a wearable concept then to propose actions of leverage and perpetuation to this sector.

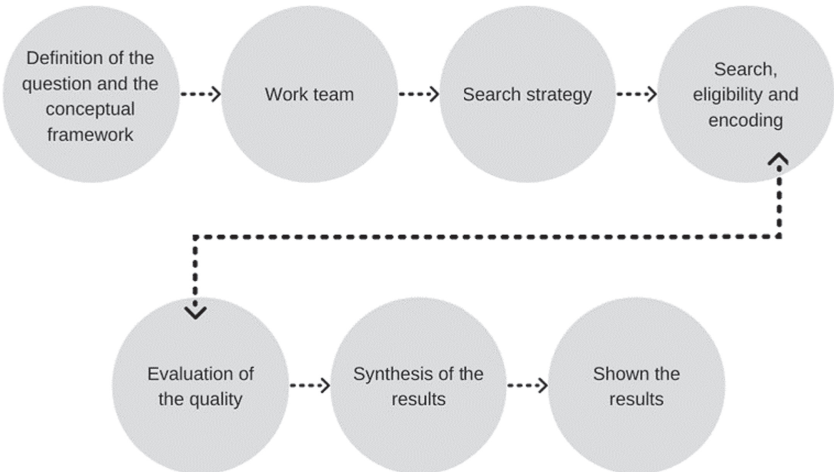
3. Methodology

According to Silva and Menezes (2005), the research seeks ways to solve problems still unanswered; therefore, it is a reflective and critical procedure which, to obtain relevant and well-founded results, must indicate how it was carried out, making it possible to be contested and verified (Dresch, Lacerda, & Antunes, 2015).

In this research, the proposed working method combines systematic and rational practices that contribute to obtain the desired results (Collatto, Dresch, Lacerda, & Bentz, 2018; Marconi & Lakatos, 2010). For this research, we applied the systematic literature review method, which seeks to answer a question put forth by the researcher and uses systematic and explicit methods for collecting and analyzing the material found (Morandi & Camargo, 2015). Figure 1 shows how this study was conducted.

The *definition of the question and the conceptual framework* arise from the interest in identifying how wearable technologies are inserted in the fashion value ecosystem, initially detecting who the actors that belong to this ecosystem are. Regarding the conceptual framework, this research is configurative since keywords were searched *a priori* considering the topic of wearable technologies and their insertion in the fashion value ecosystem. The *work team*, in turn, comprised the researchers who worked on the project and those who had knowledge about the theme and the methodology used.

The *strategy* was the elaboration of a set of keywords on the proposed topic. Databases were selected to perform the search: *Ebsco*, *Scielo*, *Web of Science*, *Scopus*, *Emerald* and gray literature (Google Scholar and reports of funding agencies) (Morandi & Camargo, 2015).



Source(s): Adapted from Morandi and Camargo (2015)

Figure 1.
Method for the systematic literature review

Saturation was the selected search strategy, and no timeframe was defined. When entering the combination of keywords, the Boolean operator "AND" was used, which helped minimize search bias. To select the documents, we performed three analyses: titles, abstracts and studies selected for a full reading. This way, 6,881 titles were found, of which 902 studies (scientific articles, technical reports and journal articles) were selected for summary analysis, and 349 were finally included in our study, as Table 1 shows.

Out of the final 349 documents, 15 addressed ecosystems and value or supply chains and were read in full. This way, a second exclusion of titles was carried out: studies not relevant were excluded, leaving 13 documents (see Table 2 in Section 4).

The completion of *search*, *eligibility* and *encoding* represented the operationalization of the study. Thus, when conducting the search, adherence and relevance to the theme were considered as inclusion criteria, whereas documents that did not address the studied context were excluded. The *evaluation of the quality* of primary studies centered on the contents of the documents, that is, whether they addressed value ecosystem, value chain, supply chain, among others, concerning the researched theme. The similarity of primary studies was considered and synthesized in a heterogeneous way.

For the *synthesis of the results*, we applied interpretative criticism. It was performed in three moments: initially by separating materials that discussed value ecosystem, value chain, supply chain, among others. Then, these materials were indexed using the software ATLAS.ti. The second step was also performed in this software, which listed the elements/actors that composed the fashion value ecosystem. Finally, in the third step, a table was created containing the elements/actors, which was analyzed again in order to reorder the elements/actors the documents presented, excluding or joining similar ones.

Using the qualitative data analysis software allows grouping similar data into blocks related to the issue, hypothesis or topic of interest and its relations (Miles, Huberman, & Saldana, 2013), thus enabling an efficient, consistent and systematic analysis of data management (Gibbs, 2014). Based on this process, the framework for this research was prepared, and we *show the results* in the following section.

4. Results

This section discusses the data obtained in the systematic literature review, its results and the fashion value ecosystem model from the perspective of wearable technologies. Therefore, as described in Section 3, we selected 13 documents, as Table 2 shows. We selected these documents because they discuss ecosystems, value chains or supply chains of the fabric and clothing sector, defined in this study as *fashion*.

The study of EURATEX (2004) was used as a basis for the development of the ecosystem proposed for this study, as it presents the actors and the interconnections between them, beginning by the presentation of the extraction industry and ending in the reverse chain. The study's main objective was to plan strategies for the future of the fashion industry, allowing

Systematic literature review results – wearables

Database	Results	Analyzed abstracts	Included studies
Scielo	9	9	2
Web of science	24	24	19
Scopus	41	41	6
EBSCO	56	56	10
Emerald	53	53	17
Gray literature	6,698	719	295
Total	6,881	902	349

Source(s): Prepared by the authors

Table 1.
Search results

No	Authors	Study title
01	EURATEX (2004)	European technology platform: for the future of textiles and clothing – a vision for 2020
02	Pinar and Trapp (2008)	Creating competitive advantage through ingredient branding and brand ecosystem: the case of Turkish cotton and textiles
03	Strauss, Sundjaja, Johnson, Gandhi, Wong, & Yoo (2010)	An NYCEDC study
04	Salonoja (2013)	Bridging the equity and entrepreneurial gaps in the Finnish fashion industry
05	Corner & Stride (2015)	A local fashion ecosystem, the next step toward an east London fashion cluster
06	Mengi (2017)	Reconsidering the knowledge ecology in fashion industry: a metaphorical approach
07	Fontell & Heikkilä (2017)	Model of circular business ecosystem for textiles
08	Wang (2018)	Brief analysis on closed-loop ecosystem of textile and clothing recycling
09	Oksanen *et al.* (2018)	In search of Finnish creative economy ecosystems and their development needs-study based on international benchmarking
10	Sandberg, Pal, & Hemilä (2018)	Exploring value creation and appropriation in the reverse clothing supply chain
11	Lin (2018)	The structural characteristics of the innovation ecosystem: a Fashion case
12	Kaplanidou (2018)	Digitalization in the apparel manufacturing process
13	Chen (2019)	Value creation by SMEs participating in global value chains under industry 4.0 trend: Case study of textile industry in Taiwan

Source(s): Prepared by the authors

Table 2.
List of articles

access to resources for the development of research and innovations. Thus, that study shows the need to know the actors that belong to the fashion sector to propose future actions, corroborating the objectives of our own study.

The other studies discuss other topics, such as the creation of competitive advantages for the fashion sector. Chen (2019) and Mengi (2017) used a local fashion ecosystem to understand the clothing sector; however, Chen (2019) demonstrated the relevance of using technology for the participation of small companies in the fashion supply chain, whereas Mengi (2017) proposed integration between the textile and clothing sectors.

Corroborating this stance, Salonoja (2013) noted that the lack of integration and collaboration between clothing companies might result in the ecosystem's underdevelopment and difficulties in obtaining external capital. Pinar and Trapp (2008) explained that strategies for brand promotion and product differentiation might promote increased competitiveness of textile products.

Sandberg *et al.* (2018) explained value creation and appropriation processes in a reverse clothing chain to demonstrate sustainability in the fashion value ecosystem. Wang (2018) addressed the need for changes in the manufacture and disposal of clothing, pointing out solutions to minimize impacts generated in the production of garments. Both authors present a comprehensive view of the actions and the members in the reverse chain.

Corner and Stride (2015) and Strauss *et al.* (2010) addressed the search for the development of the local fashion industry. The evidence shows the relevance of cities as global fashion centers through the promotion of jobs, training and workspaces (Corner & Stride, 2015), helping and informing interested parties regarding the future of the fashion industry (Strauss *et al.*, 2010).

In turn, Oksanen *et al.* (2018) analyzed the ecosystem of the creative economy in three countries and provided recommendations for the fashion industry. Lin (2018) explored technological innovation as a means to expand the image of an innovation ecosystem.

Kaplanidou (2018) demonstrated the influence of digital transformation of different companies on the clothing industry, emphasizing the importance of Greek clothing manufacturers in understanding digital technologies. Finally, Fontell and Heikkilä (2017) presented a circular business ecosystem for textiles and clothing and explained the circular economy principles in the textile context, the main material flows and the types of actors present in the value chain.

Thus, after reading the documents listed in Table 2, the elements/actors present in the models and the subdivision of the products derived from them were extracted, as Table 3 shows. Then, as described in Section 2, a qualitative analysis was performed on the actors, using a qualitative statistics software as a tool and excluding duplicates or conflicting names.

Based on data on the actors, the conceptual model of the fashion value ecosystem was designed from the perspective of wearable technologies, as Figure 2 shows. The proposed ecosystem has as its core business a "technological clothing product." This definition was adopted because wearable products had different descriptions in the literature review (Mardonova & Choi, 2018). This diversity reflects in the separation carried out by Richter (2018), who pointed out six types of marketed wearable products. In addition, Dehghani and Kim (2019) pointed to clusters of occurrence of terms related to wearable devices and product diversity. Corroborating this stance, O'Nascimento (2020) shows several types and classes of wearable products.

As a premise, Moore (1996) stated that for the core business value and leverage ecosystem, there are dimensions defined as *extraction industry*, *textile transformation industry*, *goods/clothing industry*, *retail*, *customers*, *reverse chain* and *electronics*. Furthermore, external actors/support who provide services to the actors directly linked to the core business were added to our model and labeled as *distribution*, *professionals* and *others*.

The *extraction industry* is divided into natural and chemical fibers, as this subdivision determines the fabric to be produced and the other processes they perform. The *transformation industry* remodels the fibers, converting them into threads and later into fabrics through weaving and improvements that increase the quality of threads, whether chemical, natural, conventional, frictional or technological (EURATEX, 2004).

The *goods/clothing industry* develops and produces the clothing items, technological or not. In the proposed model, this dimension briefly addresses the main actors involved in the clothing manufacture process, namely, development and modeling, cutting and sewing (Kaplanidou, 2018; Mengi, 2017) and improvement (EURATEX, 2004). Thus, because it is a wide-scope, complex sector, other actors are present and vary according to the market segment considered.

The *retail* dimension relates to sales and embodies two possible forms of distribution: physical and online (Chen, 2019; Fontell & Heikkilä, 2017; Strauss *et al.*, 2010). The current rise of shopping apps has highlighted online retailing, which now has more followers than ever (Fontell & Heikkilä, 2017). The *customers*, in turn, are divided into *conventional*, seeking to supply their individual needs, and *unconventional*, such as medicine consumers, which obtain products intending to supply collective needs (EURATEX, 2004).

When reviewing the documents in Table 3, we noticed the presence of *reverse chains*. They are inserted in the ecosystem and divided into *disuse* and *recycling* (EURATEX, 2004; Fontell & Heikkilä, 2017; Strauss *et al.*, 2010).

Finally, *electronics* is part of the computer and nanotechnology industry that produces components and parts. Thus, this actor supplies materials to build technological garment products. They can be inserted in both the extraction industry, thus producing technological fabrics that will later be used as raw material and the goods/clothing industry during the finalization of the product (Wood, 2018). Therefore, sensors, nanotechnological goods, miniaturization, such as sensing, wireless communication or nanotechnology, become available to the manufacturing and goods/confection industries (Eidenhammer, 2018). Currently, *wearable technology* is considered the joining of electronics/informatics and clothing and accessories (Wood, 2018).

Other actors (external/support) may directly or indirectly influence the functioning of the ecosystem, such as intermediaries/negotiators, legislation, infrastructure and education/courses.

Table 3.
Excerpt of the list created from the analysis of studies – actors/products

Actors/products		EURATEX (2004)	Pinar and Trapp (2008)	Strauss *et al.* (2010)	Salonoja (2013)	Corner and Stride (2015)	Mengi (2017)	Fontell and Heikkilä (2017)	Wang (2018)	Oksanen *et al.* (2018)	Sandberg *et al.* (2018)	Lin (2018)	Kaplanidou (2018)	Chen (2019)
Extraction industry	Natural fiber	x						x					x	
	Fiber	x												
Transformation industry	Petrochemical industry													x
	Chemical industry	x												
	Chemical yarn industry	x						x	x				x	x
	Weaving factory								x				x	x
	Processing	x												
Goods/Clothing industry	Seam						x						x	
	Clothes factory	x		x		x		x	x					x
	Dyeing and finishing (embroidery, prints)			x										x
Distribution	Branded clothing companies													x
	Wholesale			x										
	Service providers/ materials	x	X							x				x

(continued)

Table 3.

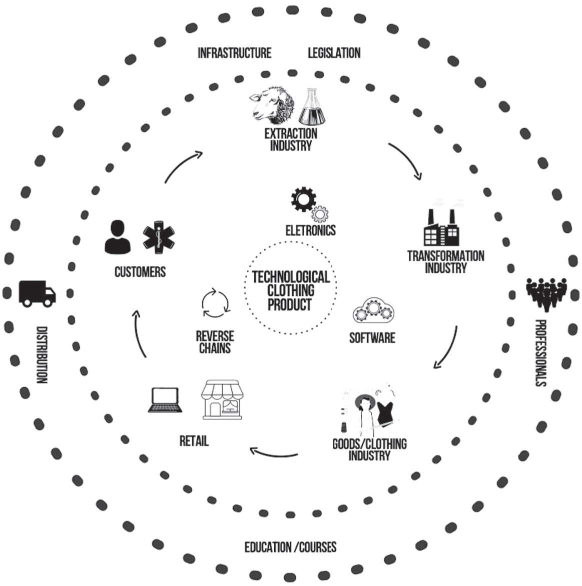
Actors/products		EURATEX (2004)	Pinar and Trapp (2008)	Strauss *et al.* (2010)	Salonoja (2013)	Corner and Stride (2015)	Mengi (2017)	Fontell and Heikkilä (2017)	Wang (2018)	Oksanen *et al.* (2018)	Sandberg *et al.* (2018)	Lin (2018)	Kaplanidou (2018)	Chen (2019)
Professionals	Human resources/capital		x		x									
	Intermediaries		X											
	Designs/creators			x		x		x	x	x		x		
	Fashion editors						x							
	Commercial brokers/classifiers										x			
	Entrepreneurs									x				
	Fashion bloggers						x					x		
	Craftsman											x		
	Public relations											x		
	Hairstylist						x							
	Fashion experts	X												
Customers	Buyers						x	x		x	x	x		x
	Public sector/government	x			x							x		
	Old customers				x									
Retail	Retail			x				x						x
	Boutiques						x							
Reverse chains	Repair (DIY)							X						
	Waste management	X						x	x					

(*continued*)

Table 3.

Actors/products		EURATEX (2004)	Pinar and Trapp (2008)	Strauss *et al.* (2010)	Salonoja (2013)	Corner and Stride (2015)	Mengi (2017)	Fontell and Heikkilä (2017)	Wang (2018)	Oksanen *et al.* (2018)	Sandberg *et al.* (2018)	Lin (2018)	Kaplanidou (2018)	Chen (2019)
Other	Machinery and equipment producers and suppliers	X												
	Software producers and suppliers	X												
	Other intermediate services	X												
	Support services	X												
	Operations and value creation (brand)		x											
	Value delivery (brand)		X											
	Consumer preferences and desired experiences (brand)		X											

Source(s): Prepared by the authors



Source(s): Prepared by the authors

Figure 2. Conceptual model of fashion value ecosystem

Therefore, these actors comprise an essential dimension in the ecosystem since they disseminate knowledge and legitimize technological product development in different sectors.

Distribution and *professionals* refer to the availability of products or technical services for product development. They are divided into textile/apparel, services, technology providers, content providers, intermediaries/negotiators and transport/logistics. For example, considering *distribution*, there are software suppliers that permit the reading of the identified data. In the *professionals* dimension, there is a need for specialized people to analyze this data and insert this technology in the clothing product, including many technological areas, such as fashion, computer science, engineering and the Humanities, like Medicine and Psychology. Therefore, these professionals have joint action, with variable intensity depending on the technological product to be developed.

The model shown in Figure 2 represents the reality of the complex fashion value ecosystem, lists the actors and demonstrates their interconnection. Unfortunately, the fashion value ecosystem model from the perspective of wearable technologies is incomplete because, depending on the product, actors need to be inserted or excluded. The following section presents the final considerations of the study.

5. Final considerations

Identifying the actors in the fashion value ecosystem enables confirming the complexity in this sector and understanding its functioning. Furthermore, by designing a conceptual model using an ecosystem approach (Moore, 1996), it is possible to verify the interconnection between actors aiming at the sector's functionality and leverage. Finally, even though organizations, entities, actors and the society in general, which gravitate around as complex a business such as fashion, are not structured and identified, they are part of a value ecosystem (Serrano *et al.*, 2018). Therefore, the proposed objective was achieved, i.e. to identify the participants (actors) and create a fashion ecosystem model from the perspective of wearable technologies.

In terms of relevance, in our systematic literature review, no studies included wearable technologies in the discussed fashion ecosystems, nor their relations with other industries. However, the use of wearable technologies in numerous industrial sectors is evident (Fernández-Caramés & Fraga-Lamas, 2018). Furthermore, these technologies add safety at work by monitoring body data (Mardonova & Choi, 2018). Besides, according to Zhang *et al.* (2020), wearable technology can be helpful for governments and health departments to control pandemics and track people consistently and precisely.

In addition, wearables are an emerging subject that needs further research to insert this technology in productive sectors and enable the development of sensors, information technology, data fusion techniques, material science, communication technologies, flexible batteries and storage facilities (Zhang *et al.*, 2020). Thus, it becomes interesting to systematically identify this sector's possible limitations and leverage points with the insertion of wearable technologies aiming to increase its competitiveness. Systematically analyzing the sector, it is possible to understand the existing complex relations, which would not be possible to be done linearly (Sterman, 2000). In addition, it is necessary to use different approaches for business effectiveness (Chen, 2019).

Although the results of this study are satisfactory, there were limitations to it. The first is that the model considered secondary data, the studies and documents shown in Table 2. Also, the search universe resulted in documents concerning ecosystem models, value chains and supply chains. Thus, many studies had to be excluded.

The second limitation refers to the structure of the value ecosystem presented in Figure 2, which followed Moore (1996) and was divided into *core business*, *direct dimensions* and *external actors/support*. Thus, the positioning of the actors may not follow a proper order due to the sector's complexity. Because of this, we propose for further works the validation of our conceptual model through interviews with experts, making it possible to neutralize the limitations. It is also crucial to identify existing differences in the current processes of product development and production.

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