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## Co-design and Mass Customization in the Portuguese footwear cluster: an exploratory study

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### Abstract

In the present, consumers tend to be more knowledgeable and interventive, requiring an active role in the way how they relate to brands and products. To meet this need, several sectors of the fashion industry saw this as a market opportunity and adopted approaches of Collaborative Design and Mass Customization. The footwear sector was not indifferent to this new paradigm of creation, production, distribution, and consumption, and several worldwide brands adopted innovative strategies. In Portugal, despite footwear being a mature industry with a strong tradition and worldwide recognition, it is necessary to continuously invest in innovation-based competitiveness, exploring the opportunities of Industry 4.0. Thus, the study seeks to analyse this important sector of the Portuguese economy, in order to perceive the acceptance, vision, and expectations regarding the approaches of Co-design and Mass Customization. In this way, seven companies with national relevance were studied based on a questionnaire survey. Findings show the industry's interest in Co-design and customization, despite the concern about the effort and risk associated to the transition and implementation of the productive approach. Relevant data for the development of collaborative models of footwear customization are gathered in this study.

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*Keywords:* Footwear; Collaborative Design; Customization; Portuguese Footwear Industry

### 1. Introduction

#### 1.1. Theoretical framework

Business viability is related with up-to-date demand information, which must be considered vital in the strategy of a company. It is vital to deeply know customers, in order to identify their needs and expectations [1]. According to Espejo and Dominici [2], nowadays, consumers tend to be more knowledgeable and there is a tendency to this awareness increase giving even more importance to: the quality and reliability of the acquired and given information; technical specifications; and cocreation of value. The experience and active intervention are the current key drivers of customers' expectations, requiring an active role in the way how they relate to brands and products. According to several authors, the mastery of this new level of interaction is crucial to promote the customer's engagement and brand loyalty [3–6]. At the

same time, the culture of individualism and hedonism is valued and encouraged by the contemporary society, moderating the consumer behaviour and interactions. It is in this environment of eagerness that the desire of personalization and self-affirmation rise and lead the consumer motivations [7,8]. To meet these needs, several sectors of the fashion industry saw this as a market opportunity and adopted approaches of Collaborative Design (Co-design) and Mass Customization (MC). The paradigm of Industry 4.0 contributes to this new consumers profile, giving solution to their need of interaction, customization, and changing the relations between consumers and producers [9]. The footwear industry has not been indifferent to this trend, resulting in the significant growth of solutions for customization in the last years. Indeed, the worldwide sector is witnessing the transition from Mass Production to Mass Customization, creating new opportunities and business models supported by Industry 4.0 and the growing concern with sustainability and ethical fashion [10,11]. The

Portuguese footwear industry has strong ancestral roots being mainly a “low-tech” and traditional sector, very dependent on intensive manual procedures and techniques. Although having experienced difficult periods in the past, nowadays it is a successful case of resilience in the Portuguese economy, with a solid impact in the national balance of trade in terms of export payments. Therefore, despite Portuguese footwear being a mature industry with a strong tradition and worldwide recognition, it is necessary to continuously invest in innovation-based competitiveness, exploring the opportunities of Industry 4.0 [12–14]. However, there is a lack of knowledge and systematic data related to Co-design and MC practices.

### 1.2. Objectives and methodology

This study seeks to analyse part of the Portuguese footwear sector, in order to perceive the acceptance, vision, and expectations regarding the approaches of Co-design and MC. Due to the relevance of the sector, and to fulfil the lack of empirical knowledge in this field, it is important to determine the sector interest regarding the growing world trend towards the adoption of Co-design and MC strategies. An exploratory study was carried out based on a literature review and a self-completed questionnaire, as suggested by Saunders et al. [15]. The research was supported on the vision and experience of a small sample of companies specialized in the production of footwear and components. The sectorial organization *Centro Tecnológico do Calçado de Portugal* (CTCP) contributed actively in the definition of the sample as network facilitator – approach used in several studies [12,16,17]. To correspond to the previously established objectives, it was necessary to obtain exhaustive and in-depth data of the reality in analysis. Thus, the nature of the study is based on qualitative elements and the strategy for data collection was founded on multiple case studies. This methodology is used in several scientific researches of MC and footwear, namely Consortium EuroShoe [18] and Marques et al. [12]. The intentional sample selection was based on companies and brands that have in common the specialization and constant innovation in the production of footwear and its components, and at the same time reflects some diversity by the type/style of product – allowing a more holistic view of the cluster [19]. The questionnaire was initially tested in a small group of practitioners. The final questionnaire was applied to seven companies by email and in person, between July and September of 2018.

## 2. Theoretical foundation

### 2.1. Mass Customization and Co-design

MC is a production strategy focused on offering customized products on a large scale, and satisfying customers’ specific needs at a reasonable price [20]. It is mostly based on modular architecture of product/service design, which allows tailoring by customer intervention [21]. According to Fogliatto et al. [22], MC is a response of the industry to consumers’ demand for affordable customization of products/services, considered “customer centric”. In its turn, Co-design is a creative practice that privileges any act of collective creativity shared by two or

more people, as it is applied across the entire design process [23]. In this way, MC and Co-design are intrinsically connected concepts [24,25]. Both are user-centred, allowing collaboration, interaction, and articulation between different players in order to accomplish the purpose of satisfying mutual needs. The key element of MC is customer co-design, and that is the differentiation factor from other strategies. Customers perform Co-design activities within a list of options and pre-defined components [26]. Thus, the concept of “collaborative customization” becomes clear [25].

### 2.2. Challenges of Mass Customization based on Co-design

Zhang and Tseng [27] indicate that although the MC based on Co-design allows to satisfy more adequately the customers’ needs, and offers a good business opportunity, it is necessary to consider that customization is a very complex process. The main challenge implies having the capability of combining the efficiency and scale economy of Mass Production with the possibility of manufacturing small batches, and even a single product, of very diversified and personalized products while ensuring an affordable price for the customer [28]. Facing this condition and making MC a viable opportunity for all players has become the main objective of many scientific studies in the last years. The solutions are focused on modular product design, cross-functional coordination, reconfiguration of the production chain, supply chain coordination, investment in constant innovation, integrating technology, improving processes and developing specific software to support MC [22,29–31]. According to Aqlan et al. [32], the optimization could be achieved by adjusting the process layout to higher efficiency configuration allowing to provide greater utilization and more flexibility of resources. To assist resource management, Jianxin and Helander [33] propose the development of an electronic configure-to-order platform for customized products. This holistic interface allows to achieve a synergy of sales force automation, product design, manufacturing planning, and supply chain management. Attending to all the solutions, the answer to reduce the complexity of MC could be associated with the implementation of Industry 4.0. According to Roblek et al. [9] and Hermann et al. [34], Industry 4.0 consists in the convergence of industrial production, information, and communication technologies. This trendy paradigm is currently a top priority for many companies and academic institutions. It relates to the Internet of People (IoP), the Internet of Things (IoT), and the Internet of Everything (IoE), promoting the integration of smart technology to assist people and machines in the execution of their tasks. In this way, connecting people (suppliers, manufacturers and consumers), things (products and machines), and data (real-time local or global information) allows to develop new ways of creating products that result in new industrial processes and methodologies based on collaboration. This recent paradigm is also based on the decentralization of decisions, allowing consumers to become decision-makers and playing a more active role in the process, as result of a deep relation with Co-design and product customization [9,35]. Despite being an initially intricate process, MC has become a very successful strategy. At the

beginning of the millennium, MC might be viewed as a promising manufacturing strategy, especially for niche market producers. However, it is now a dominant form of production in several sectors of business-to-business and business-to-consumer, high-end and major consumer markets [22].

### 2.3. Footwear customizable dimensions and ornamentation

Boër and Dulio [36] determined three customizable dimensions of footwear: style/aesthetics, fit/comfort and functionality/performance. The style/aesthetic dimension is the most immediate, common, versatile, and easier to intervene. The customer chooses the design according to pre-defined attributes. The size adjustment/comfort is more complex to manage because it involves the size width and shape of the shoe (dependent of the shoe last), and the selection of components and materials. It depends on individual specificities that go beyond simple size selection. The functionality/performance dimension is an optimization based on the selection of the manufacturing processes and components to best match the user's intentions of usage. Analysing cost impact on design, manufacture and sales, the style customization is the more viable and attractive dimension, since the intervention is mainly at an aesthetic level. Thus, this dimension is the most common and appreciated by customers and producers. However, there is no empirical evidences that confirm if this dimension is the most relevant to create value [26,36].

There are several possibilities and techniques to customize products, supported by technology and digital interfaces. Footwear products present some limitations associated to the performance of manufacturing process, materials, and components [37]. Still, there are several attributes that can be changed in the modular structure of a shoe, namely sole (bottom module), upper (surface module) and accessories [37]. Generally, the intervention at the materials level is easy, given the large range of possibilities used in the upper module, from traditional ones (most types of leather), to textiles and new polymeric materials, innovative tanning systems, and smart textiles. Yet, the shape of the sole module could be more difficult to intervene in traditional production of injected soles [13,36,38]. Thus, the range of footwear materials is massive. The main properties required are resistance, durability, flexibility, cushioning and ability to adjust and shape to the shoe configuration [39]. The intervention at the colour level, while keeping the same material, is the easiest way to intervene at the aesthetic level of the shoe customization in all the modules [36]. Laser cut and engraving is another technique used in the surface design of footwear materials, allowing to customize texture and cut details in materials, in order to ornament with all over patterns or localized element [40,41]. Embroidery is a recurrent ornamenting technique used in footwear design that is easily accessible to customization by industrial processes such as computerized embroidery [37,41]. A different way to intervene in the footwear design and production, allowing a higher level of customization and small batches of production, is the seamless knitting process. This is an innovative kind of production in footwear sector that ends with the traditional stitching assemble process and provides an ultralightweight seamless upper, combining aesthetic and

comfort features – e.g. knitted running shoes from *adidas*, *Nike* and European project “Instant Shoe Project” [42]. Another potential way to create a new freedom of footwear design and production is the 3D-Printing process, based on additive manufacturing. It is expected that the 3D printing becomes an important tool for the development of online sales and customization of footwear. It could be applied to the production of components such as accessories or soles, but it has a great potential to disruption by allowing the development of full printed shoes. Part of this potential is already implemented and allows to print 3D layers directly on top of a textile substrate that can be used as upper module of a shoe. It is possible to easily create new designs, choose different textures, colours and gloss level [43–46].

### 2.4. Consumer expectations and behaviour

Customization based on Co-design could allow further means to express consumers' uniqueness, by designing products based on their own personal choices, in order to look different from the rest of the social group. This is particularly true for products related to personal appearance such as wearable items and apparel [47]. In addition, this active intervention may also provide symbolic benefits (intrinsic and social) to the consumer, for example the pride-of-authorship effect. However, to achieve this sense of success and avoid frustration and stress, it is essential to ensure that the customer is capable of performing the task [26]. Co-design and customization allow developing products created not only by the brand (endorsing the corporative image and brand value), but also by the consumer, generating a significant sense of belonging in the emotional relationship with objects. The emotional involvement dimension is strongly advocated by Emotionally Durable Design and Emotional Design approaches [2,48]. The customization of the product consequently leads to customer loyalty, if trust is established between the customer and the company or brand, and the customer is satisfied with the created product [35]. Although the final price of the product tends to be higher, the willingness to pay a premium price for customization is a recognition of the increment of value conceded to a product that better meets consumer's needs, than the best standard product attainable [49]. However, this customers' active participation results in an increase of expectations. The consumer of a customized product has higher expectations than if he/she was buying a standard product, coming from massification [50].

### 2.5. Information and communication technology

Information and communication technology are the key drivers to an effective and efficient customization process based on Co-design. Tools focused on sales, product design, manufacturing and supply chain management have commonly been implemented [22,37]. The cocreation of value is directly related to the development and diffusion of digital technologies that assist consumers, but also producers. It is important to understand that together, consumers and manufacturers can create an active system of shared meanings through recurrent communications. In this way, the development of

communication tools, such as digital interfaces and Co-design platforms, is fundamental to maximize strengths and minimize weaknesses of Co-design and MC approaches [2,26]. Collaborative customization usually requires a digital interface, mostly online, and due to the fact of the order precedes the production (build-to-order or make-to-forecast production), the online sales channel tends to be the most convenient for customers and producers, saving time and minimizing the effort required to make a purchase and obtain the good [51,52]. Moreover, according to literature, online channel tends to have lower associated costs than traditional (offline), and also prices tend to be lower online than in stores, due to the minor service levels and thus inferior operating costs on the Internet [53].

### 3. Questionnaire

The self-completed questionnaire used in this work is divided in eight questions. The first one is a short open-ended question, and the remainder are five level Likert scale (1-very low to 5-very high) answers. The first question is divided into four points to characterize the participant and the company/brand. The second question intends to know the participant's vision regarding the adoption and practice of customized footwear approaches compared to traditional production methods concerning: process complexity, costs, value creation, profits and business opportunity. The third question allows to determine the interest of the company/brand in the customization dimensions (style, comfort and functionality). The fourth question aims to analyse the viability of different ornamentation techniques applied in collaborative footwear customization (selection of materials, colours, integral design of the model, laser cut/engraving, embroidery, seamless production and 3D printing accessories/parts, soles or the entire model). The fifth question focuses on the participants' perception of consumers' curiosity, trust, self-identification with the creation, product receptivity, willingness to pay, and emotional involvement with the product. The sixth question aims to determine the level of suitability of sales channels for custom footwear – traditional (offline) or online. The seventh question allows to check the importance given to the development of communication tools to assist the industry and the consumer in the process of footwear customization. The eighth question consists in the authorization agreement to use the obtained data for scientific research and publication, in which all the respondents agreed.

### 4. Results and discussion

Question 1: demographic information.

Results: seven companies contributed: *Aloft, Lda.* (injected soles producer); *AMF, Lda.* (footwear manufacturer, owns technical footwear brand *Toworkfor*); *Carité Calçados, Lda.* (footwear manufacturer for several international brands); *Camilo Martins Ferreira & Filhos, Lda.* (footwear manufacturer, owns premium footwear brand *Centenário*); *Alberto Sousa, Lda.* (footwear manufacturer, owns fashion footwear brand *Eureka*); *Fortunato O. Frederico & C<sup>a</sup>, Lda.* (footwear manufacturer, owns fashion footwear brand *Fly London*); *Ropar, S.A.* (footwear manufacturer, owns ergonomic

footwear brand *Arcopedico*). This set of companies has a significant relevance in the national panorama, with own brands and/or with production focused on export.

Question 2: compared to traditional production methods what do you think about Mass Customization?

Results: there is some disparity in the results (Table 1) of process complexity, particularly in the answers related to product design and customer support. This can be justified by the intrinsic specificities of each type of product. The companies/brands with higher fashion attributes (*Carité, Centenário, Eureka, Kyaia* and *Ropar*) indicate higher complexity of those processes. This is a reflex of making products more related to personal appearance and symbolic benefits [47], and being in direct contact with final customers, who have high expectations [50]. However, the obtained mean of each considered element of complexity is in accordance with literature – MC is a complex process, particularly in supply chain coordination [22,27].

Table 1. Answers to question 2.

	Aloft	AMF	Carité	Centenário	Eureka	Kyaia	Ropar	Mean
Process complexity:								
- Product design	2	2	4	4	5	4	4	3,6
- Order	3	3	4	3	4	4	3	3,4
- Suppliers	4	4	5	4	4	4	4	4,1
- Production	4	3	4	4	4	4	4	3,9
- Distribution	3	2	4	3	3	4	2	3,0
- Sales	2	2	4	3	3	4	2	2,9
- Customer support	2	2	5	3	3	4	3	3,1
Costs with:								
- Production	5	3	5	5	3	5	5	4,4
- Materials stock	4	4	5	4	2	4	3	3,7
- Production stock	4	4	5	4	2	4	3	3,7
- Distribution	2	3	4	3	2	4	2	2,9
- Sales	2	2	4	3	2	5	2	2,9
- Customer support	2	4	4	3	2	4	2	3,0
Product final price	3	4	5	5	3	4	4	4,0
Brand value creation	3	5	4	4	4	5	3	4,0
Overall profitability	2	3	4	3	3	3	1	2,7
Business opportunity	2	4	3	2	4	4	2	3,0

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

The results connected to costs are mostly consistent and coherent with the literature – in general, MC tends to increase the costs associated with all production chain, especially in the transition phase. Analysing the mean of all costs, it is possible to observe that those associated with production are considered the ones with the greatest impact – in accordance with literature.[22,29–31]. *Eureka* is the exception, stating that the costs are lower. One possible reason for this insight is that this brand already integrates production systems and technology of Industry 4.0 that can support customization, such as 3D printing of component [34,35]. Another disparity is observed

in what concerns the results of costs associated with sales, which would need a deeper analysis – no evidence has been identified to justify this. In turn, as expected, the results regarding final price of the customized product (mean) show that it is higher than the price of a standard product, coming from the massification – coherent with literature [49,53]. Regarding the results of brand value creation, a positive assumption is noted – participants consider that customization has a significant impact on the creation of value for the brand, agreeing with literature [2,49,54]. When asked about overall profitability and business opportunity, the results show some disparity. This is reflex of the sector itself, in which companies seems to be traveling at different speeds [12]. However, the means reveal a positive perception of both aspects. Despite footwear customization being a new approach already in practice, it is still seen with some apprehension for the more conservative companies and with traditional approaches.

Question 3: how do you rate your company/brand interest in the following approaches of customization?

Results: as expected, the results (Table 2) translate the core specialization of each company/brand, revealing the intention to maintain their businesses. Nevertheless, the obtained means indicate coherence with literature – customization of style is the most dominant dimension [26,36].

Table 2. Answers to question 3.

	Aloft	AMF	Carite	Centenario	Eureka	Kyaia	Ropar	Mean
Type of customization:								
- Style	3	4	3	3	3	5	3	3,4
- Comfort	4	4	3	2	2	3	4	3,1
- Functionality	5	5	3	2	1	3	3	3,1

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

Question 4: how do you classify the viability of the following processes in the collaborative customization of footwear?

Results: the answers (Table 3) show some disparity related with the specificities of each product. However, attending to the means, it is possible to see a higher viability of interventions based on selecting colours (the easiest and more superficial type), followed by selecting materials – as expected [26,36]. Simple and useful techniques as laser cut/engraving are well accepted, followed by embroidery and seamless technology. A full design intervention was classified as moderate. However, attending to each answer, it is possible to observe a deep disparity. Companies/brands with less complex products considered that a deeper intervention on product design by the customer is highly feasible. The 3D printing technology is well accepted for accessories/components, but not so much for soles, and even less for full model printing. The more conservative participants consider that, at the present time, this technology is not capable of offering an effective solution.

Question 5: how do you describe the consumer behaviour regarding collaborative customization of footwear?

Results: the results (Table 4) show more coherent answers and evidence a significantly clear perception of the market

interest for collaborative customization of footwear. Best results are related to the perception of customers’ self-identification with the creation, curiosity, product receptivity and emotional involvement. Even the more conservative participants are aware of the emotional factor, agreeing with literature [2,47,48]. However, participants reveal some apprehension regarding the customers willingness to pay, diverging from the literature [22,26,49].

Table 3. Answers to question 4.

	Aloft	AMF	Carite	Centenario	Eureka	Kyaia	Ropar	Mean
Customization based on:								
- Material options	4	4	4	4	4	5	4	4,1
- Colour options	5	4	4	5	4	5	4	4,4
- Full design	5	1	3	1	2	3	4	2,7
- Laser cut/engraving	5	3	4	4	3	5	3	3,9
- Embroidery	5	1	4	3	2	5	3	3,3
- Seamless technology	4	5	4	1	2	3	2	3,0
- 3D printing accessories	4	4	4	2	2	5	2	3,3
- 3D printing soles	2	4	4	1	3	2	2	2,6
- 3D printing full model	2	2	4	1	4	2	2	2,4

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

Table 4. Answers to question 5.

	Aloft	AMF	Carite	Centenario	Eureka	Kyaia	Ropar	Mean
Perception of customer behaviour:								
- Curiosity	5	4	4	4	4	5	3	4,1
- Trust	5	4	3	3	4	4	3	3,7
- Self-identification	5	4	3	3	5	5	3	4,0
- Product receptivity	5	4	4	4	5	4	3	4,1
- Willingness to pay	3	3	3	2	3	3	3	2,9
- Emotional involvement	4	4	5	4	5	5	3	4,3

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

Question 6: how do you classify the suitability of the sales channel for this type of product?

Table 5. Answers to question 6.

	Aloft	AMF	Carite	Centenario	Eureka	Kyaia	Ropar	Mean
Sales channel:								
- Traditional (offline)	2	3	2	1	1	3	3	2,1
- Online	5	5	5	4	4	5	2	4,3

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

Results: attending to the mean of the results (Table 5), participants consider the online sales channel the most

appropriate, thus agreeing with literature [51,52]. The gap between Ropar's answer and the others is not understood.

Question 7: how do you rate the importance of developing communication tools that assist the industry and the consumer in the footwear collaborative customization process?

Results: attending to the mean of the results (Table 6), participants recognize the vital importance that communication tools have in the customization process based in Co-design, in agreement with literature [2,26]. Again, the gap between Ropar's answer and the others is not understood.

Table 6. Answers to question 7.

	Aloft	AMF	Carite	Centenario	Eureka	Kyria	Ropar	Mean
Importance of communication tools development	5	4	5	4	5	5	2	4,3

Likert scale: 1 – Very low; 2 – Low; 3 – Moderate; 4 – High; 5 – Very high

## 5. Conclusions and final considerations

Findings show the interest of the Portuguese footwear industry in Mass Customization (MC) based on Co-design, despite the concern about the effort, costs and risk associated with the transition and implementation. Thus, a moderate acceptance of footwear customization based on Co-design was observed. Although the obtained results are not totally clear by showing some disparity, mostly associated with intrinsic specificities of each company/brand/product, it was possible to confirm the potential interest on this “customer centric” approach. The Portuguese footwear cluster is very traditional and offers some resistance to change and adaptation to new paradigms. However, if the sector wants to improve competitiveness, then the companies need to have a more aggressive and cohesive innovation strategy. Entering new markets with more sophisticated products focused on good design and own brands, with high differentiation and quality, is a strongly recommended strategy encouraged by this study and in agreement with Marques et al. [12]. Thus, a MC approach based on Co-design could be a solution, as indicated by the results of this paper. Therefore, in order to overcome the limitations, achieve more efficiency, become mutually appealing and contemplate deeper footwear customization, it is necessary to improve all the production-chain processes and integrate smart technology, very related to Industry 4.0 – the obtained results are coherent with literature [40]. In this way, the market demand and the potential of Industry 4.0 are vital key drivers that companies/brands must contemplate in their strategies to correspond to the footwear customization challenges in the short to medium term. This paper contributes to the ongoing discussion centring around the Co-design approach, and the MC system applied to the footwear industry, pointing the perception of the Portuguese cluster within both the scientific (literature review) and the practitioners’ (industry contribution) communities. In this way, the purpose of contributing to fulfil the lack of empirical knowledge in this field was accomplished.

Limitations of the paper result from its scope and research method. The sample selection made by CTCP (sectorial organization) could be an assumed potential biased process. Focusing on seven companies, relevant contributions of others might be left unnoticed. Thus, it is not meant to be representative, only exploratory. However, the obtained data allow to bring new elements of discussion and analysis. The present study is expected to be continued, in order to give it a greater foundation and scientific legitimacy, using the relevant data obtained for the development of collaborative models of footwear customization.

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