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Business Model Scenarios For Digital Textile Microfactories

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Abstract

In several industries the concept of Microfactories has been developed and their potentials are still subject of research and development. Also in the Textile and Clothing Industry this concept of a digitally networked end-to-end digital design and production process finds its first realizations in different applications. Such a Digital Textile Microfactory can cover a complete value creating chain comprising all design and production steps from the customer to the ready-made product. It relies on virtual models of the process steps involved, as well as of the materials, the products, and the customers. The digital backbone allows for speed, efficiency, high quality, and deep consumer interaction leading to a great innovation potential in a wide area of applications and Business Models. They range from B2B types, where they can support and speed up the prototyping phase of product development (sampling) up to B2C settings for the innovative production of individualized products, including reordering as well as event-driven production and locally centred production. But in spite of the potential benefits of a Digital Textile Microfactory, there are still just a few realizations seen in the industry due to investment risks and uncertainty with regards to new Business Models.

The goal of this paper is to explore Business Model scenarios for a Digital Textile Microfactory that uses digital textile printing as a core process. We first describe the economic characteristics of the Textile and Clothing Industry, and then the digital technology and process underlying such a Digital Textile Microfactory. Based on this description, we then explore different B2B and B2C application scenarios – developed in previous European and German research projects – and settings for related Business Models.

Keywords

Microfactory; Digital Textile Printing; Business Model; Textile Industry; Digitalization

1. Introduction

The Textile and Clothing Industry (TCI), and especially the sectors of fashion and apparel as well as home and household textiles are characterised by global value chains and by high dynamics. Reasons for this include the megatrend individualization [1], worldwide competition, as well as recent technology and process innovations [2]. The traditional reactions of cost reductions, outsourcing of production to low-wage countries or unspecific stimulation of product demand trying to restore mass production are not promising for many new Business Models, and thus do not always offer an adequate answer to the extreme short product life cycles for many companies in the fashion sector.

Specific additional challenges in the fashion sector arise from the facts that first, product development usually takes relatively long time, as it involves manual process steps and iterated production of physical samples and second, end-consumer demand is highly volatile, resulting in stock-outs or wasteful overproduction.

Moreover, apart from these economic characteristics the TCI is faced with social and ecological grievances, such as child labour and environmental pollution through chemicals playing a role in end consumers' purchasing decisions. This can be seen in approaches such as Circular Fashion, Sharing Economy [3] and the consideration of sustainability aspects, e.g. ecological footprint, use of resources, cradle-to-cradle approaches or the large number of different labels and certificates, signalling sustainability aspects towards customers.

Digital technologies deriving from the vision of Industry 4.0 offer great potential to address these challenges for the TCI. Solutions for value creation networks and production using intelligent networking [5], taking into account the possibilities of flexible production, adaptable factories, customer-centric solutions, optimised logistics, use of data for new Business Models and resource-saving circular economy [6], that have proven to be beneficial to other industries can also be applied to the TCI.

Among these approaches Microfactories have recently been subject to research and development [7] and offer new possibilities for the TCI in the form of a Digital Textile Microfactory (DTMF). A DTMF is an end-to-end digitally networked development and production process for textile and clothing products. Its digital backbone allows for speed, efficiency, high quality, and deep consumer interaction leading to a great innovation potential in a wide area of applications and Business Models. A DTMF can provide solutions for efficient development and production of individualised products in small lot sizes, being fast and flexible in a more sustainable production and supply chain.

Consistent digitalization along the entire value chain and the associated information transparency as included in the DTMF also offer solutions to issues of ecological and social sustainability.

Within the next sections of this paper the basic principles and process steps of a DTMF will be presented (section 2), followed by a description of different B2B and B2C Business Model scenarios for the TCI. In particular, these Business Models address firstly the production of individualised products, the sampling of prototypes, the re-ordering (of best-sellers) and the event-driven and locally centred production by using different kinds of settings of the DTMF. They will be discussed in depth in section 3 and summarized in section 4.

2. The Digital Textile Microfactory

The first forms of Microfactories were described in Japan in the 1990s [8]. The DTMF has already existed as a technical implementation in different forms and settings for several years. The Adidas Group demonstrated one form with its Speedfactory for individualised running shoes [9]. Currently, DTMFs exist for three product groups: Knitted fabrics, home textiles, and clothing made from textile surfaces.

The DMTF covers the complete value creating chain comprising all design and production steps from the customer to the ready-made product using these benefits of digitalization and, in most applications or settings, geographical proximity of the production steps. The operations rely on virtual models (digital twins) of the process steps involved, as well as of the materials, the products, and the customers. This digitalization allows effects regarding **flexibility** (deep consumer interaction), **speed** (availability), **efficiency** (less physical waste), **high quality** (no ramp up process), and **personalization** (lot size one). These effects will be picked up in section 3 and assigned there to specific application cases, in order to show their relevance and possible influence, besides the resource savings by using digital twins as long as possible (described in section 3).

In general, the traditional textile production workflow involves manual, labour-intensive steps from creating a design to sewing the final garment [4]. The DTMF approach reduces the long, time-consuming production steps to a minimum, especially in the development step, and ensures a continuous integrated workflow, e.g. with the help of the following value creation steps in a DTMF that uses digital textile printing on textile surfaces as a core process:

- **Body Scanning:** There are already 3D body scanning technologies that allow the generation of digital twins and a virtual try-on in a 3D simulation programme. This can be used for made-to-measure production and can help to determine body data on demand in order to integrate measurement data into existing processes. This enables the body scanner to replace the tape measure with digital measurements on an individual avatar. As a result, the measurement data can be reused and compared in the long term [10].
- **3D/Design**: The basis of a DTMF is the development of creative design in CAD, where garments with real materials (colours/texture) are digitally mapped, e.g. onto individual avatars (virtual models). Thus, in this design step avatars that were previously created with the body scanner can be imported to adapt and grade cuts to individual measurements [11]. The realistic representation makes the interaction of material, cut and body in particular visible (e.g. virtual fit analyses) [12] which can save samples and thus development costs and effort to a considerable extent. With the help of a 3D simulation, the design is then prepared for cutting out [11].
- **Raster Image Processing (RIP)**: After the 3D design, a ‘print and cut’ file is created, which contains a multi-layer file and displays different layers, for example for contours and textures. For this purpose, identifying QR codes and position markers are integrated into the production order for later position recognition. It facilitates the colour-compliant preparation of the design data for the digital printer [11]. This workflow enables more efficient and resource-saving production compared to traditional ones. It is also suitable for on-demand productions, as the workflow can be flexibly adapted.
- **AR/VR**: Virtual interaction options such as Augmented and Virtual Reality (AR/VR) can also be integrated into the DTMF, representing a digital showroom – a virtual place where collections can be viewed virtually. There are already digital and interactive 3D product presentations that can be used at the point of sale [13]. This saves the time-consuming procedure of handing over collections (via photo creation, manual uploading of files, entering in different tools) as it has been practised in previous processes.
- **Digital Printing**: In the next step, the textiles are printed with the individual designs using the core process, the digital printing process [14]. The production files required for this are generated directly from a 3D simulation environment. The colour-accurate preparation of the design data is made possible with the help of the aforementioned RIP programme. The designs are printed on transfer paper, using sublimation equipment. The following thermo-fixing process is accomplished using the calender, thus ensuring a perfect print [11].
- **Cutting Out:** With the help of a camera, the identifying QR codes and position markers make it possible to identify the exact position of each component and the material then can be cut out, entirely automatically [11].
- **Handling**: The cut outs then can be sorted, in a completely automated process, using a robotic arm with a grab claw transporting them, directly and as efficiently as possible, to the assembly department [11].
- **Assembling**: Finally, the individual components are joined together to form a finished product, e.g. by means of sewing or ultrasonic welding machines [11].

3. Business Models for DTMF

A DTMF bears great innovation potential in a broad range of applications and Business Model scenarios, covering B2B settings, where they can improve the prototyping phase of product development up to B2C settings for the innovative production of single-lot, on-site, on-demand individualized products [15,16]. Those benefits of DTMF so far are not widely seen and realised in the TCI due to perceived investment risks and uncertainty with regard to new Business Models. Although there are different generic approaches for Business Model Innovation [17,18] the specific characteristics of the TCI call for a closer look at potential DTMF Business Models.

The economic use of DTMF is a dynamic problem and depends on external conditions and internal design fields and their mutual influences. External conditions include product requirements and dominant market mechanisms, such as trends, competition, demand and delay effects. The internal design fields also include a large number of aspects, such as the setting of the DTMF, the necessary number of machines per value-added stage (scaling), the possible throughput of the DTMF (dimensioning), the operational classification of the DTMF and the associated unit costs and margins to be realised, the resulting throughput times and the competence and personnel requirements.

Besides the economic dimension of sustainability of DTMF – leading to reduced costs and increased margins – there are ecological aspects that refer mainly on '… reduction of waste and transportation needs' [15]. Even digital textile printing as a core process and standalone technology is able to reduce the consumption of ink, waste, energy, and water in comparison to screen printing [15] and offers for all applications potentials to resource saving. The social dimension is met by the local or regional production being close to the customer, focusing together with the data-based transparency on socially responsible innovation and production [15].

Using the DTMF as an integrated concept covering all value creation steps in one place, as described in section 2 (possibly excluding the body scanning), there are at least four application cases that can serve for Business Models, as indicated above: individualization, sampling, reordering and event-driven and locally centred production. Those application cases have been developed in European and German research projects [2,14]. Especially the following ones, labelled as **individualization**, **sampling** and **event-driven and locally centred production** are an outcome of the European Research project 'A Knowledge-based business model for small series fashion products by integrating customized innovative services in big data environment', where they have been derived from different production scenarios [2]. The application case **reordering** has been developed in the wake of German research projects, dealing with the digital transformation in the apparel and clothing industry [14]:

- **Individualization**: Companies can participate in the megatrend of individualization, which is estimated to have a positive impact on turnover next 10-15 years [19], even though there are still few quantitatively reliable statements on turnover development. Nevertheless, cautiously estimated turnover increases of 0.5% to 1% per year are assumed here. Specific customer requirements and wishes can thus be implemented quickly and efficiently in production. This leads to interactive and customer-driven value creation processes. Individual product designs also provide the customer with a special experience. As digitalization increases the range and choice of products and technologies, and consumer demands for uniqueness, quality and service grow. Accordingly, this can again lead to increased competition for individual products and cost pressure [14] and addresses more or less all three sustainability dimensions. Effected in a positive manner are **flexibility** (deep consumer interaction), **speed** (availability), **high quality** (no ramp up process) and **personalization** (lot size one).
- **Sampling**: Working within a digitalised process, using digital twins as long as possible instead of physical samples offers significant cost reductions in new product development. Recent

investigations within the framework of the AiF research project ‘Digital Collection Development’ (IGF project 20892 N) at the Center of Management Research of the German Institutes of Textile and Fiber Research Denkendorf (DITF) in the area of small series in the workwear sector show saving potentials in the new product development and sample production process of 10% to 20% for a product line (e.g. a specific pair of work trousers) [20]. These savings result from the elimination of several physical (fabric) samples and the faster recognition and elimination of undesirable developments by simulating matching repeats, colours etc. Savings can even double when considering new product lines to be developed. Thus, noticeable cost savings of 20% to 40% are possible in product development, especially in sampling, which can then account for up to 1% of total turnover. This in turn simplifies communication and coordination processes between those involved within the process and thus reduces environmental impact by producing fewer physical samples. Digital sampling, however, also means changes from the perspective of the employees, including training, instruction and qualification as well as high investment costs for new systems (e.g. 3D tools) [2]. Business Models here can lead to services offering to re-invent parts or the whole sampling process and effect in particular **efficiency** (less physical waste) and **high quality** (no ramp up process) addressing mainly economic and ecologic dimensions of sustainability.

- **Reordering**: In the case of sold out and highly demanded products a fast and flexible response would allow to satisfy customers’ needs and profit from them. This could include small batches from lot size one up to a big number of products in order to keep the customer’s loyalty and avoid overproduction in times of unstable demand. Hence, the benefits here are twofold: the production could be oriented due to a conservative forecast or demand with less warehousing costs, and the possibility to retain the customer, who will wait for the desired product, which will convert a lost sale into a so-called backlog [21]. Hence, **speed** (availability) and **high quality** (no ramp up process) are mainly addressed in a positive way and contribute strongly to economic dimensions of sustainability.
- **Event-driven and locally centred production**: Concerning several events, such as seasonal, sport and cultural ones, there is an opportunity to sell products – often quite simple ones, like T-shirts or scarfs – to customers being fans, supporters, showing to public their opinion etc. This demand is often not predictable and does not allow long delivery times. This asks for a production in the surrounding area, a local production, with a fast and flexible response time. There is in general no time for ramp-up and complicated design and accessories, as the time to market is very close.
  The locally centred production, not only for events, as it is proclaimed in the trend of nearshoring [22], allows to react fast and flexible by using known structures, common rules and conditions [2]. This Business Model requires a powerful infrastructure (using digital twins) and a lot of know-how as well as qualified partners and workers. It could increase the risk of losing touch with new developments due to missing global influences. This means that innovative products must constantly be brought to market and organizational structures must be adapted [2]. In addition, there is the opportunity to choose resources in an environmentally oriented way, to produce under local conditions and thus to comply with socio-ecological standards, and the extent of product counterfeiting can be reduced, which often is a huge problem [23]. This effects positively **flexibility** (deep consumer interaction), **speed** (availability), **efficiency** (less physical waste), **high quality** (no ramp up process), and **personalization** (lot size one). Furthermore, all dimensions of sustainability are addressed to some extent here.

These Business Models can be supported by the following settings of the DTMF [24]:

- **Factory-in-Shop**: A DTMF placed in a retail and/or selling environment focusing on customer or consumer interaction with a fast throughput and production time.

- (**Standalone) Factory:** A DTMF with upscaling capacities allowing to produce a fast and flexible on-demand production, e.g. high-speed printing using multiple printers.
- **Factory-in-Factory:** A DTMF as a workplace in a textile or garment factory for dedicated production jobs (sampling, lot-size one).
- **Technological Centre (Lab):** A DTMF as part of a technological centre or a lab (following the fab lab concept) for design, experimenting, co-creation of products as well as training and education purposes of processes.

In general individualization (1) can be supported by 'Factory-in-Shop' and '(standalone) Factory', sampling (2) by 'Factory-in-Factory' and 'Technological Centre (Lab)', reordering (3) by '(standalone) Factory' and event-driven and locally centred production (4) by 'Factory-in-Shop' and '(standalone) Factory' as shown in Table 1:

Table 1: Settings of DTMF for different Business Models

Business Model	Positive Effects (in addition to resource saving) on	Dimension of sustainability addressed	DTMF Setting	Type of Business Model
Individualization	Flexibility, speed, high quality, personalization	Ecologic, economic, social	Factory-in-Shop, (standalone) Factory	B2C
Sampling	Efficiency, high quality	Ecologic, economic	Factory-in-Factory, Technological Centre (Lab)	B2B
Reordering	Speed, high quality	Economic	(Standalone) Factory	B2C
Event-driven and locally centred production	Flexibility, speed, efficiency, high quality, personalization	Ecologic, economic, social	Factory-in-Shop, (standalone) Factory	B2C

These settings allow in general to use the DTMF as integrated process including all steps presented in section 2 in one place for a fully networked production from body scanning, 3D simulation of the individual garment to digital printing and cutting out to the finished product. In addition, there are other settings (especially sampling) that allow e.g. the production of samples in digital networked forms widely spread over different countries, using only parts of the integrated concept DTMF [24].

Encouraged by the DTMF economic benefits, a trend towards in-house manufacturing for several fashion retailers can already be observed (using the Factory-in-Factory setting), to control their supply chain and to have the benefit of speed to market as well as sustainability [25].

4. Summary

Recent trends and developments in the TCI call for an increased use of digital technologies in order to address changing market and sustainability needs. In this paper we have shown potential Business Models for a fully networked DTMF that uses digital textile printing as a core process step, starting with body scanning, 3D/Design, RIP, AR/VR and completing with cutting out, handling and assembling.

There are four scenarios (or application fields) for Business Models in the areas of B2B and B2C that can use a DTMF in order to cope with the challenges and yield profit. Therefore, the positive effects on the scenarios are indicated and assigned to each of them as well as the dimensions of sustainability. The demand of customers for personalised products with high quality leads to the most noticeable application, the individualization that can be answered by fast local value chains as well as by organizational structures that create new opportunities through end-to-end digitalization. Besides individualization of products (in small lot sizes), there are other promising applications and Business Models for sampling, reordering and event-driven as well as locally centred production, which benefit in the same way from digitally networked end-to-end digital design and production processes. Different settings of DTMF match the presented Business Models.

As an integrated and local production site the DTMF offers a fast (reducing the time to market), flexible and sustainable answer, especially for the fashion and clothing industry. But it has to be adapted according to the Business Models and settings with regard to the specific external conditions (product requirements and dominant market mechanisms, such as trends, competition, demand and delay effects), as well as the internal design fields (like setting of the DTMF, number of machines per value-added stage the dimensioning, personnel requirements) and their mutual influences in order to reach out for the greatest possible economic and sustainable success.

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References

[1] Kuhl, J., Krause, D., 2019, Strategies for Customer Satisfaction and Customer Requirement Fulfillment within the Trend of Individualization, Procedia CIRP, Volume 84, 130-135.

[2] Winkler, M., Stellmach, D., Tilebein, M., 2019. Neue Szenarien der Wertschöpfung für Geschäftsmodelle in der Textilwirtschaft, in: Schröder, M. (Ed.), Logistik im Wandel der Zeit – Von der Produktionssteuerung zu vernetzten Supply Chains, Springer Fachmedien, Wiesbaden, pp. 601–626.

[3] Curtis, S.K., Mont, O., 2020. Sharing economy business models for sustainability, Journal of Cleaner Production, Volume 266, 121519, 1-15.

[4] Lushan, S., 2018, Technology disruptions: exploring the changing roles of designers, makers, and users in the fashion industry, International Journal of Fashion Design, Technology and Education, Volume 11, Issue 3, 362-374.

[5] Kiel, D., Müller, J.M., Arnold, C., Voigt, K.-I., 2019. Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0, International Journal of Innovation Management, 21(8), 1-34.

[6] Federal Ministry for Economic Affairs and Climate Action, 2022. What is Industrie 4.0?, URL: https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html, (28.01.2022).

[7] Montes, J., Olleros, F., 2019. Microfactories and the new economies of scale and scope, Journal of Manufacturing Technology Management, 31 (1), 72-90.

[8] Mishima, N. Tanikawa, T. Ashida, K., Maekawa, H., 2002. Design of a Microfactory, in: 7th Design for Manufacturing Conference, Tumer, I. Y. (Ed.), American Society of Mechanical Engineers, New York, pp. 103-110.

[9] Adidas Group, 2019. adidas deploys Speedfactory technology at Asian suppliers by end of 2019, URL: https://www.adidas-group.com/en/media/news-archive/press-releases/2019/adidas-deploys-speedfactory-technology-at-asian-suppliers-by-end-2019/ (14.01.2022).

[10] Shen Y., 2020. 3D Technology and Tailored Clothing, 3rd International Conference on Global Economy, Finance and Humanities Research, European American Chamber of Commerce and Industry, URL: https://www.clausiuspress.com/conferences/LNEMSS/GEFHR%202020/GEFHR2020022.pdf (20.12.2021).

[11] DITF Denkendorf, 2017. MICROFACTORY 4 Fashion, URL: https://www.ditf.de/en/index/more-informations/microfactory.html (20.12.2021).

[12] Lin Y.-L., Wang M.-J., 2014. Digital Human Modelling and Clothing Virtual Try-on Proceedings, Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia, January 7 – 9, 1914-1918.

[13] Vuframe, 2021. Unleash your products with interactive 3D, URL: https://en.vuframe.com/ (20.12.2021).

[14] Moltenbrey F., Fischer T., 2021. Retail 4.0 – Digital Customer and Retailer Feedback to Garment Development, Journal of Textile Science & Fashion Technology, 8 (2), 1-4.

[15] Tilebein, M., 2019. Small, Smart and Sustainable, Digital textile (2), World Textile Publications Ltd, Leeds, UK, 60-63.

[16] Tilebein, M., 2017. New Business Models, IoTex – Technical Brief, Issue 1, 38-39.

[17] Johnson, M. W., Christensen, C. M., Kagermann, H., 2008. Reinventing Your Business Model, Harvard Business Review, 86 (12), 57-68.

[18] Osterwalder A., Pigneur, Y., 2013. Business model generation: A handbook for visionaries, game changers, and challengers, Wiley&Sons, New York.

[19] Peters R., Goluchowicz, K., Richter S., 2020. Perspectives 2035: A guide to the textile future | Summary, URL: https://textil-mode.de/en/research/zukunftsstrategie-perspektiven-2035/ (14.01.2022).

[20] AiF Datenbank, 2022. Digital Collection Development – Final report of the research project (IGF No. 20892 N), URL: https://www.aif.de/foerderangebote/igf-industrielle-gemeinschaftsforschung/igf-projektdatenbank.html (27.01.2022).

[21] Absi, N., Kedad-Sidhoum, S., Dauzère-Pérès, S., 2011. Uncapacitated lot-sizing problem with production time windows, early productions, backlogs and lost sales, International Journal of Production Research, 49:9, 2551-2566.

[22] Anderson, J., Berg, A., Hedrich, S., Ibanez, P., Janmark, J. and Magnus, K.-H., 2018. Is apparel manufacturing coming home? Nearshoring, automation, and sustainability – establishing a demand focused apparel value chain, McKinsey & Company, URL: https://www.mckinsey.com/~/media/mckinsey/industries/retail/our%20insights/is%20apparel%20manufacturing%20coming%20home/is-apparel-manufacturing-coming-home_vf.pdf (20.12.2021).

[23] Meraviglia, L., 2018. Technology and counterfeiting in the fashion industry: Friends or foes?, Business Horizons, Volume 61, Issue 3, 467-475.

[24] Artschwager, A. Winkler, M., Brunner, L., 2022. Textile Microfactory and Distributed Production – Digitalisation as a Game Changer for Backshifting – A response to changing environment and consumers. Why Textile Microfactories and Digitalisation will change the Future of Textiles, White Paper, URL: www.ditf.de/ (22.03.2022).

[25] McKeegan, D., 2018. Why Textile Micro-Factories Will Change the Future of Fashion, Which PLM, URL: https://www.whichplm.com/why-textile-micro-factories-will-change-the-future-of-fashion/ (20.12.2021).

Biography

Marcus Winkler (*1965) studied economics at the University of Stuttgart and has been working for the Center of Management Research of the German Institutes of Textile and Fiber Research Denkendorf (DITF), since 1995. The research of Dr. Marcus Winkler includes Internet 4.0, Supply Chain Management and Business Models in national and international research and consulting projects.

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Meike Tilebein (*1966) has been the Director of the Institute for Diversity Studies in Engineering at the University of Stuttgart since its establishment in 2009. Prof. Dr. rer. pol. Dipl.-Ing. Meike Tilebein also heads the Center of Management Research of the German Institutes of Textile and Fiber Research Denkendorf (DITF) that supports the textile industry's digital transformation.