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Designing Business Models for Sustainable Mass Customization: A Framework Proposal

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Abstract

In the last three decades, the idea of mass customization has been broadly discussed in management literature as a business model for companies that offer goods to customers with heterogeneous needs. At the same time, the discussion on business models that deal with the increasing customer demand for more sustainable products has gained importance. In the research field of mass customization, there is a lack of research that integrates the new affordances of sustainability into mass customization based business models. With our study, we contribute to this research gap by developing a set of generic sustainable mass customization business model patterns. For this purpose, we first describe the enablers for mass customization and for environmental sustainability separately. In a second step, we combine both perspectives and propose a set of seven generic patterns that serve as guidance for integrating sustainable mass customization on a business model level. Finally, we provide an application of our framework to the Consumer Electronics industry showcasing ideas for practical implementation.

Key words: *Business Models, Framework Proposal, Mass Customization, Sustainability*

1. INTRODUCTION

Mass customization (MC) has been regarded by the European Commission as one of the main value drivers of a sustainable European economy [1]. Developing and implementing business models that directly incorporate both these elements (MC and sustainability) could enable a shift towards that direction. While standard approaches for developing business models solely incorporate economic considerations [2–4], research in the context of sustainable business models has recently acknowledged the importance of incorporating sustainability in a company's business model [5,6]. In the MC field of research, however, there is a lack of studies that integrate sustainability considerations into MC based business models. Research in the field of Sustainable Mass Customization (SMC) is limited to few publications. So far no research article exists for the specific context of SMC business models. Hence, this article aims to strengthen the knowledge in this area through the development of a generic framework for the systematic development and implementation of SMC business models. Following a qualitative approach, this paper proposes generic business model design elements that can be used when integrating SMC on a business model level. Building on the insights of a literature review in the distinct domains of SMC business models, a set of business model innovation (BMI) workshops

have been conducted by an expert panel in collaboration with the Turkey based TV producer Vestel Electronics. Through this specific industry focus, the article especially contributes to the implementation of SMC within the consumer electronics (CE) industry.
This article is structured into five main parts. First, the theoretical background is outlined including an introduction to BMI and SMC. This is followed by a methodology section. Third, the framework development is presented. This includes (1) an overview on the requirements for successfully integrating MC in business models, (2) an overview of the requirements for successfully integrating sustainability in business models, and (3) a description of the framework proposal that combines both perspectives into a single business model perspective. The framework development section is followed by an outlook on applying this framework to the manufacturing of TVs. Finally, the article concludes with a short summary and opportunities for further research.

2. THEORETICAL BACKGROUND

2.1 Business Model Innovation

Over the recent years, the term BMI has become *en vogue*. After all, the object of interest is the progression and redevelopment of all entrepreneurial action: the business model. Among other definitions, a business model is the concept of the management how, at what time and by exploiting which resources a company may create value for its customers and, in return, be rewarded for doing so [4]. Consequently, working on a business model represents one of the core activities of the management.
BMI is based upon an understanding similar to that of the modern strategy process [4]: both, BMI and the modern strategy process, periodically boost the upcoming strategy with great involvement of the entire organization. This requires a suitable toolset that can empower every member of the organization to participate in this core process. The goal is to provide participative and interactive methods, which permit a creative and simultaneously systematic derivation of new business models following the idea of Design Thinking [7]. This user-oriented approach is based on the following core steps: understanding, observing, point-of-view, idea generation, prototyping and refinement [8,9]. Usually, an interdisciplinary project group conducts all of these core steps and multiple iterations are applied.
Several modern approaches to BMI have been established in recent years with the most widely known approach being the Business Model Canvas (Figure 1) developed by Swiss business theorist Alexander Osterwalder [3]. By applying this model, companies can visualize existing and potential new business models structured alongside factors of importance, such as product creation, distribution channels, customer relationship or cost and revenue composition. Consequently, this model was chosen as the basis of the proposed approach in developing a framework for the development of new SMC based business models. However, the Osterwalder [3] business model canvas only functions as an intermediate step between two other essential elements of BMI: the generation of potentially exploitable ideas; and their examination with respect to their suitability as the foundation of a new business model.

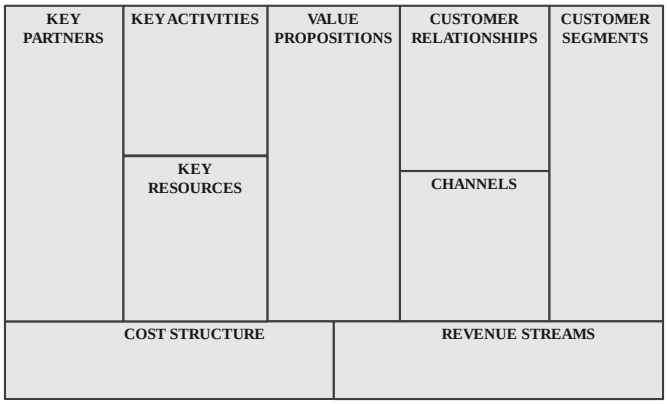


Figure 1. Osterwalder's Business Model Canvas [3]

2.2 Sustainable Mass Customization

Recently, the synergies between MC and sustainability have been cited frequently in research [1,10–16]. However, few evidence is available at the practitioner level [14,17,18]. The lack of practical results is mainly due to the relative novelty of the SMC concept on the one hand, and to the high complexity of the sustainability improvement assessment and subsequent identification of the importance of the various enablers including those related to MC on the other hand [10]. The achievement of SMC implies a strong involvement of customers and the undertaking of the product re-design following a Life Cycle Approach (LCA). For these reasons, specific guidelines for the Design for SMC (DfSMC) have to be developed. These guidelines stem from the integration of the existing Design for eXcellence (DfX) approaches developed on the basis of the mapping of MC and sustainability requirements and constraints [11].
Medini et al. [14] also stress the commonalities among MC and sustainability enablers. The most cited benefit of MC on environmental sustainability is waste reduction. It is achieved by the replacement of the forecast based mass production system by a "zero storage" build-to-order system where finished products are produced at the exact moment and in the exact quantity the customer requires [11,12,14,17,19,20]. A longer product lifespan can also be achieved due to the fact that MC products are designed to satisfy specific customer needs and because they often make use of durable classic designs [11,12]. The increased product lifespan results in a reduction of resource and material consumption because the products are replaced at a slower pace. On the contrary, the high level of customization can decrease the positive effects of product reuse put forward by the circular economy concept, unless one assumes that product modularity eases product modification [12,21]. Another driver of SMC is the establishment of closed loop supply chains

supporting product reuse, refurbishment and recycling, facilitated by the adoption of modularity and DfX guidelines [12,14]. The impact of the adoption of MC in the establishment of a closed loop supply chain and the management of the product extended life are less explored subjects in previous literature. Both aspects call for significant BMI because they redefine the relationships between customers and producers, with a stronger accent on the notion of Product Service Systems (PSS) [12,13,16]. In general, they affect various elements of the Business Model Canvas, such as for instance the value proposition, key partners, or revenue streams.

In summary, research indicates that a number of environmental benefits along all phases of the product life cycle can be achieved by shifting from a forecast based mass production system to an on-demand MC based system. Environmental benefits include the reduction of inventory (e.g. raw material consumption) and waste production, a longer product lifespan, the adoption of eco-innovations at feature level, the establishment of closed loop material flows, etc. The methods applied for achieving these objectives and ensuring a well-balanced SMC require a stronger integration of the main drivers of MC and sustainability. Moreover, these methods have to be assessed and tailored according to the specific demands of the application context because the product nature and the availability of innovative technologies are both crucial for exploiting all potential benefits of SMC.

3. METHODOLOGY

The results of this paper are based on a four-step procedure. The first step was to review the existing literature on the underlying idea of BMI, the goal being to identify how business model patterns are created and used as generic blueprints for new business models (see section 2.1.). Furthermore, the literature review involved screening two additional fields of research separately: MC and sustainability due to the limited research on SMC related to BMI.

Based on the outcomes of the literature reviews, a set of BMI workshops were conducted as a second step, in which experts from the fields of BMI, MC, and sustainability assessment collaborated with practitioners from the TV manufacturing industry. In the course of these BMI workshops, business model elements were collected considering the required transformations proposed by MC literature and MC practice examples [22]. The business model elements were then structured and distributed to four requirements for successfully implementing MC (“MC enablers”), which were previously derived from literature and validated in the course of the BMI workshops. Analogously, environmental business model elements were selected if they outlined how different customization options offer opportunities for enhancing the sustainability along all stages of the product life cycle. This was followed by the distribution of all sustainability business model design elements to a set of six requirements for successfully integrating sustainability (“sustainability enablers”), which were also previously derived from literature and validated in the course of the BMI workshops.

The third step involved the development of generic SMC business model components by combining the MC and sustainability design element clusters previously identified. Seven SMC business model components were designed by creating a Business Model Canvas for each cluster and by describing each section of the canvas.

Finally, the SMC framework and the respective SMC business model components were applied to the TV industry and possible scenarios for concrete implementation described.

4. FRAMEWORK DEVELOPMENT

4.1 Mass Customization Business Model Pattern and Requirements

Gassmann et al. [4] discovered that just 55 business models are responsible for 90% of the world's most successful businesses. Therefore, they came up with the so-called “Business Model Navigator” that comprises 55 blueprints of the business models they identified. One of these business model blueprints is MC. Hence, for Gassmann et al. [4], MC comprises a stand-alone business model blueprint. Gassmann et al. consider MC a hybrid strategy between “mass production” and “customization”. As a concept in BMI, it describes the attempt to combine the advantages of both concepts. In simpler terms, the goal is to provide an individualized product at the low cost of mass production [19].

The shift towards MC requires a profound system innovation along the entire knowledge and supply chain. First, designers have to adopt a new way of thinking about changing product architectures towards modularity [23–26] within well-defined solution spaces [27,28]. In the production process, the modules are very homogenous products. Production thus exploits economies of scale and specialization effects well. Already a limited number of modules directly translates into a much larger number of final products. By giving the opportunity to choose between different modules, the diverging individual customer needs are satisfied to a very high extent. In contrast to the approach of one-product-fits-for-all-customers’-requirements, however, these needs are not over-satisfied as often the case with standard products. In addition, customers do not need to pay a notable surcharge for the customization of their product because of two reasons: first, the modular composition of products; and second, the customer does not pay for the over-satisfactory elements that she does not require in the end [4,24,29]. In complex sectors, such as consumer electronics, this modularity can be created with software functionalities as well as hardware components [30]. These software features can be used as powerful tools for MC in two ways: first, customizing visual graphical user interface; and second, customizing software features of the product. A great variety of customization opportunities may be created in these ways without the need for extra inventory, extra components and production processes.

However, this can imply addition software development costs.

Second, manufacturing has to be organized differently with robust but, at the same time, adaptive processes centered on single customer orders [27,31–33]. Thus, MC companies have to implement fast and efficient build-to-order systems [32]. Furthermore, postponement strategies play a crucial role to reduce complexity in an MC product system [34–36].

A third important requirement for MC is the design of a co-creation process between the company and its customers [37–39]. The interaction within the co-creation process results in an intensified company-customer relationship caused by the "I designed it myself" effect [40]. This effect refers to the emotional attachment the customer develops towards the product and company during the customization process.

Closely related to the design of the co-creation process is the requirement for MC companies to develop and implement new kinds of (web-based) customer interaction systems [41,42]. These systems may vary according to the sector, customer base and sales channels. MC companies should be clear about their customers, their needs and desires for the selected product groups [30]. This knowledge can be achieved with customer needs research studies that may be conducted at the very beginning of the customization process, but also during the use of the customer interaction system [39,43]. With recent technological advances, adaptive products also allow for self-customization during the usage phase. MC companies, therefore, do not only have to follow point-of-sale customization strategies, but self-customization strategies. This requires a change towards platform thinking to enable interaction with the customer, possibilities for reconfiguration and upgrades during usage [18,44,45].

Considering the required transformations proposed by MC literature and MC practical examples [22], the following main MC elements have been identified as most relevant for the CE industry (based on components within Osterwalder's [3] Business Model Canvas in Figure 1):

- **Key partners**: Customer as co-designer, assembling partner and/or retailer.
- **Key activities**: Flexible production and distribution, marketing (segmented market), product and process (re)design.
- **Value proposition**: Upgradability, customization experience, specific performance & usability, "Don't pay for what you don't need", and easy-to-use promise.
- **Customer relationships**: Direct interaction with the customers (=co-creators), provision of an assisted process (e.g. through a web-based interface), goal to establish continuous relationships.
- **Channels**: The consumer choice navigation system (e.g. product configurator) as a main channel to address customers via the internet, in-store customization as a complementary strategy for retailers.
- **Customer segments**: Several niche markets targeted at the same time, high segmentation (long tail) instead of homogeneous mass market.
- **Key resources**: Choice navigation system, robust processes and flexible production system, customer (behavior) data, modular product design.
- **Cost structure**: Shift from a cost driven to a value driven business model. Cost drivers: fast (single) distribution, flexible production, long tail marketing, increase in complexity.
- **Revenue streams**: Customer experience driven revenues (price premium), additional service revenues, personal media selling, upgrade revenues.

MC Enablers	
Co-Creation *Establish an intensified (even emotional) relationship to the customers through involvement in the design process.*	**Modularity** *Offer a personal configuration without additional notable costs through combination of modular components.*
Build-to-order & Postponement *Start producing when a customer order is received and delay important differentiation to the latest possible moment.*	**Platform** *Move towards platform thinking to enable self-customization and interaction between the company, customers and other value providers.*

Figure 2. Mass Customization Design Cluster

4.2 **Sustainability Business Model Pattern and Requirements**

Most literature on the development of sustainability business models was found to be mainly conceptual. The majority of existing publications deal with the adaption or supplement of generic approaches on the description of business models scrutinizing specific business model types for the "Green Economy". Based on the work of Osterwalder [3], Lüdeke-Freund [46] constructs a general business model for a sustainable economy. This study extends the idea of Osterwalder by adding the two aspects of accentuation and expansion. Accentuation describes the orientation of the business model elements related to a sustainable economy. Expansion refers to the aspects that are not market related, such as air, water and ground. These aspects especially reflect the value of the business model. Bocken et al. developed eight archetypes for sustainable business models, which are subdivided into generic principles. They include (1) the use of waste products as a valuable input for additional production processes, (2) the change from ownership to use, and (3) the demand for a consequent reduction of energy consumption [47]. Boons and Lüdeke-Freund [6] provide a concise overview of the current state of research regarding business models for sustainable innovation.

Unlike the studies mentioned previously, the contribution of Joyce et al. [48] is entirely

methodological in nature, i.e. the development of a framework for assessing business models from an economic, social and environmental point of view. This tool, called the Triple Layered Business Model Canvas, adds two new layers (an environmental life cycle layer and a stakeholder social layer) to the original canvas [48]. This framework, however, was found to serve primarily as an assessment tool for existing business models or for refinements rather than for the development of completely new sustainable business models (and for completely new generic business model patterns as in the case of this study).

Before compiling the sustainability business model design elements, the interaction mechanisms between the different customization options and the associated environmental impacts along the product life cycle were intensely discussed and mapped (i.e. MC related areas such as hardware, software and service customization versus environmental key performance indicators such as energy, GHG emissions, materials, etc.) during the workshops held. The outcome of the mapping process resulted in a matrix that was used to identify the customization options along the entire product lifecycle that were anticipated to have a higher sustainability impact. These were the areas that were focused on, (i.e. the environmental objectives identified for the product) and incorporated into the SMC business model.

During the workshop the experts also identified sustainability design elements to be implemented and of relevance to TV producers and wholesalers. A summary of the main sustainability elements identified for the business model include (based on components within Osterwalder's Business Model Canvas in Figure 1):

- **Key partners**: many external stakeholder groups related to sustainability and corporate social responsibility (e.g. NGOs, certification bodies, policy, customers), reverse logistic partners.
- **Key activities**: Certification processes for the product, eco-design implementation and closed-loop production within the supply chain.
- **Value proposition**: Sustainability certificates, longevity of products, availability of environmentally friendly materials, conscious consumption, circular economy.
- **Customer relationships**: interacting with communities showing sustainable behavior and encouraging participation, exchange and provision of information, forming long lasting customer relationships.
- **Channels**: The product configurator presents a main channel to address sustainable product features, followed by social media and respective consumer groups, and an elaborated reverse logistic channel.
- **Customer segments**: Need to take into account which consumer group might be receptive to additional value, cross marketing concepts to address specific needs of target groups that correspond to apparently common product features.
- **Key resources**: Acquisition of new environmental data about the organization, supply chain, value chain and product itself, implementation of internal and external knowhow on sustainability and life cycle thinking, internal and external sustainability communication.
- **Cost structure**: To develop sustainable systems and offers, higher sustainable management costs should be expected unless the organization is equipped with a certain degree of organizational elements; cost reduction due to efficiency improvement.
- **Revenue streams**: Sustainable offers, options to include or add additional sustainable services (renewable energy, etc.), closed loop systems (e.g. use or selling of recycled materials, reuse parts and products).

These design elements were then aligned with the environmental objectives identified for the product, to develop sustainability clusters (described in Figure 3). The identified six sustainability clusters include: Longevity, Eco-Design, Efficiency, Awareness, Circular Economy and Dematerialization.

Sustainability Enablers		
Longevity *Increase the lifespan of the product use.*	**Eco-Design** *Implement eco-design strategies and processes for continuous environmental product improvement*	**Efficiency** *Increase material and energy efficiency in the product life cycle*
Circular Economy *Create a circular economy system to circulate materials and components on high technological level.*	**Dematerialization** *Create more value with less or no material used.*	**Awareness** *Create awareness towards sustainable values and impact of consumption.*

Figure 3. Sustainability Design Cluster

4.3 Framework Proposal for Sustainable Mass Customization based Business Models

As previously described, the goal of this study is to develop a framework for business model patterns that are directly based on SMC elements as a whole. To do so, this step of our study involved combining the elements of the MC and the sustainability design clusters. This was done through discussions with experts in the field of BMI and industry experts during the second set of workshops held that mapped MC enablers against sustainability enablers to determine suitable combinations. Table 1 shows the commonalities among the various SMC patterns. The most significant enablers in terms of SMC patterns' scope and objectives are indicated. The analysis of Table 1 shows how some MC and sustainability enablers empower specific SMC patterns. For instance, Platform, Longevity and Dematerialization are fundamental for the SMC patterns Product Stewardship

(PSS) and Additional Services. These patterns have a broader scope because they manage all phases of the product life cycle and they require the involvement of many players with supplementary competencies. In contrast, other enablers, such as Co-Creation, empower a broader range of SMC patterns. The commonality of MC and sustainability clusters among various SMC patterns shows how the company strategies can easily evolve over time following hybrid SMC patterns in order to exploit the specific benefits of each field.

Table 1. SMC Business Model Framework Pattern Development

SMC Framework / MC and Sustainability Patterns	Sustainable Solution Space Development	Recyclable and Upgradable Products	Sustainable Configuration	Produce Only What You (can) Sell	Sustainable Usage	Product Stewardship (PSS)	Additional Services
Co-Creation	x		x		x		
Modularity	x	x					
Platform		x	x			x	x
Build-to-order & Postponement				x			
Longevity		x				x	x
Eco-Design	x		x		x		
Efficiency				x	x		
Circular Economy		x				x	
Dematerialization						x	x
Awareness			x		x		

The merging of the clusters resulted in seven different SMC patterns (orientated towards the CE market) (Figure 4):

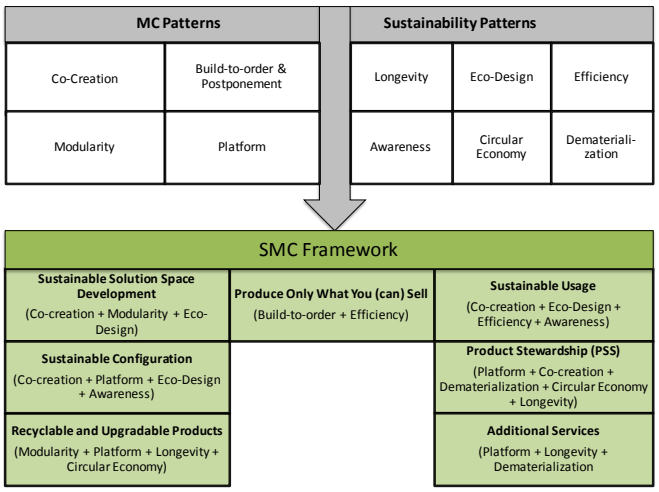


Figure 4. SMC Business Model Framework

Sustainable solution space development: This is one of the three critical capabilities to successfully offer individualized products. Here, the company defines the limited space of combinations from which the customer can choose when individualizing her product. As such, the business model has to tackle the integration of sustainability into the solution space development. This SMC business model requires the integration of the following BM patterns: Co-Creation, Modularity and Eco-Design.

Sustainable configuration: This pattern involves combining the Co-Creation pattern (MC) with Awareness and Eco-Design (sustainability). The basic idea of the so-called sustainable configuration is to incorporate environmentally and/or socially conscious choices in the user-interface [37]. This involves informing consumers about the sustainability impacts of their choice. Badurdeen & Lyanage [37] propose that product configurators should facilitate an evaluation of any desired configuration with respect to environmental and social performance. Analogue to the changes in price usually displayed, alterations in the sustainable performance resulting from the selection of certain materials has to be communicated to the customer [16]. This pattern also involves the transfer of authority from the company to the customer, who are enabled to decide what is customized and to dictate what is actually produced.

Recyclable and upgradable products: Modularity is a key enabler, particularly within certain industry sectors, for offering a wide variety of finished products while still benefiting from near mass production efficiency. If the product design is undertaken from the beginning, thinking about the whole life cycle, modularity can also facilitate product upgradability and recyclability, promoting the adoption of sustainability clusters such as Circular Economy and Longevity. Production process modification, for instance concerning disassembly, might be required to enable the application of this SMC pattern.

Produce only what you (can) sell: Instead of in-stock production, MC is usually based on the principle of Build-to-order. Thus, the final manufacturing of the individual product does not start until the customer order is received. This avoids overproduction and the need for storage facilities. In the specific context of SMC, this pattern combines the Build-to-order and postponement pattern with design elements from the Eco-Design cluster.

Sustainable usage: The Sustainable usage pattern reflects the assumption that MC concepts are suitable for improving the environmental impact during the use phase. Sustainable usage results in Longevity, upgrade options, and the efficient use of energy and materials. This pattern involves a combination of the MC cluster

Co-Creation and the sustainability clusters Awareness, Eco-Design and Efficiency.

Product stewardship: The core idea of this concept is that the company remains the owner of the product and the service related systems, and it provides a value-oriented solution for the customer instead of an item to purchase. The concept can follow two patterns - Dematerialization (same service with less material) and Circular Economy by being able to recycle materials and components in a more efficient way (company remains the product owner and the materials are not distributed in unknown systems). Furthermore, this approach offers the possibility to really tackle product and consumer systems in a very comprehensive way. Not only does it consider the whole life cycle but it also aims at improvements for the whole value chain by combining services, logistics, products and information/ communication to create a sustainable PSS. MC itself is often labelled as a PSS, however, in order to be sustainable, additional features and elements are necessary. For manufacturers and retailers wishing to develop a sustainable strategy and to benefit from a closed-loop supply chain, PSS is also an advantage because keeping the ownership of the physical products allows them to better manage all the decisions concerning the different phases of the product life cycle. The strong and long lasting relationships built with the customers through the process enables the promotion of conscious consumption and it helps widen the services offered to meet targeted sustainability objectives (see “additional services”). Therefore, they require the development of a new business model rather than the modification of an existing one.

Additional services: This pattern describes services and approaches that enhance sustainability through adding new components to the business model beyond the system boundaries, that are often still product focused (e.g. renewable energy purchase, media content). Through these services the company is able to improve the whole system in a sustainable way, if identifying and applying suitable services. This can be supported through a shift to a pay-per-use business model, which reduces customer risks and investments and provides customers with a dynamic offer continuously integrating the new services proposed by the value chain network.

5. OUTLOOK: PRELIMINARY APPLICATION

The SMC patterns proposed above are used as building blocks for the generation of SMC scenarios in the TV industry. In order to understand how to apply the strategic suggestions provided in the various SMC patterns in an operative way, research activities are planned in several steps mainly composed of brainstorming/idea generation workshops; consumer needs research in the form of interviews; and a whole design process including a design workshop. At this stage, we will reflect the results of the idea generation brainstorming workshops that we conducted with Vestel’s staff from different company departments. First, the key enablers of the various SMC patterns were presented to the staff and several operative scenarios were defined for further elaboration. Eventually, we identified the most important and feasible SMC enablers in the specific context of TV industry.

The sector specific SMC strategic guidelines are then further analyzed taking into account operational options and constraints. Thus, Vestel’s multidisciplinary team combined the information about their product and process characteristics with their knowledge about customer behavior to identify the most relevant elements composing the offered solution. The analysis embraces the characteristics of hardware, software and services and allowed the identification of elements that possibly have a relevant impact in terms of MC (influencing e.g. the aesthetic and functionalities of the TV set), and/or of sustainability (affecting e.g. the energy consumption or the material use). Before starting the search for specific solutions and their implementation in the physical mockups, the technical and economic feasibility of the modification or introduction of the various components and services as well as of their possible combinations were estimated. In the following, we present an excerpt of the identified potential customization options. Their introduction is mainly inspired by Co-Creation and Modularity on the MC side and by Eco-Design, Circular Economy, Longevity and Awareness on the sustainability side. Focusing on some of the most relevant SMS enablers allows the company to implement and even combine many of the previously identified SMC scenarios successfully:

Hardware customization: Modularity is already applied in the TV industry to some extent. It was thus decided that the hardware customization would initially be constrained to some of the modular components (e.g. front frame, stand and wall mounting options). These components have a significant impact for MC in the aesthetic dimension. The customization can be introduced more easily for these components since their modular nature prevents infringements on the production and assembly processes of the TV set. The customer may customize these components through her selections regarding type, model, color and material. This provides the customer with the opportunity to choose the most suitable combination that best fits her needs and expectations.

As part of the workshop, additional hardware customization options were created from the conceptual design ideas developed by Vestel’s Industrial Design Team to satisfy specific customer needs. An exemplary outcome of this is a customizable TV stand with a Bluetooth sound speaker module. This module addresses the observed conflicting customer need for high quality sound on the one hand and the emergence of narrower frames that do not fit high quality speaker units on the other hand.

The design of some customizable hardware components is inspired by Eco-Design principles. For instance, the introduction of a customizable stand concept produced sustainability benefits by decreasing the overall packaging size and weight of the TV. Moreover, the Industrial Design Team explored

possibilities to use more sustainable materials in the TV stands production.

Software customization and upgrades: Longevity and Efficiency are enablers for sustainability that can be achieved through software customization and upgrades. The development of new software versions and functionalities is a great example of how modularity enables a gradual extension of the Co-Creation process after product purchase. This is possible because contemporary TVs are "smarter" than their predecessors because they are equipped with advanced internet connectivity features. TVs connected to the internet can receive software updates much more easily. The possibility to upgrade software seamlessly can increase the Longevity of the product because it allows the adaption of the product to changing customer needs due to emergence of new technologies or TV watching habits. Based on the Eco-Design principle, specific software updates are developed to enforce sustainability improvements, such as the introduction of more efficient power saving procedures. For the above reasons, a company's strategy to support post-purchase software customization should be developed for both B2C and B2B customers.

Sustainable TV configurator: Co-Creation and Awareness can be enhanced by the development of an easy-to-use product configurator. The TV configurator, on the one hand, supports the consumer in the selection of the most suitable MC options and, on the other hand, allows raising their Awareness and supporting the transition towards a more sustainable purchasing behavior by presenting reliable quantitative information about the sustainability impacts of all customer choices. The sustainable choices in the TV configurator target the characteristics of the TV-set and/or those of related products and services. For instance, the configurator may offer the customer the option to choose only one of the two default components "stand" and "wall mounting" for their product in order to lower the burden on the environment. Moreover, the TV configurator may include various packaging options, including raw cardboard box without printing. This reduces printing materials and processes and thus affects environmental and economic sustainability positively. Generally, the elimination of features and components that are irrelevant to the customer fosters positive sustainability impacts, which can be realized very easily in the TV configurator. More complex but potentially advantageous modifications, such as the elimination of speakers if they are redundant in the designated use case (e.g. for visual-only advertisements), requires significant changes to the production and assembly processes and their current feasibility is still under investigation.

The introduction of specific SMC patterns requires innovations that go well beyond the appearance and the functionalities of a TV set or the corresponding configurator for selecting the MC options. For instance, new services for a better management of the product middle and end of life phases can be provided.

New Services: Circular Economy and Modularity are at the basis of the offered new services. The exponential emergence of new technologies in the electronics sector is dramatically decreasing the commercial life of products because consumers are continuously demanding the most up-to-date products. Due to the pressures imposed by various innovation streams (connectivity, smart functions, higher definition, etc.), current TVs become obsolete rapidly and "need" to be replaced by more innovative TVs despite working properly. For instance, new streaming options (e.g. Netflix, Hulu, etc.) require the latest technology in TVs. A rental system for TVs addresses this problem because it offers consumers all the newest options while minimizing the potential negative sustainability impact caused by overconsumption. Generally, a takeback system increases the likelihood of product reuse because it allows an easy refurbishment and modification of the TVs in line with consumer demands.

This way, product Longevity is increased even if the product's mission changes during its life cycle, e.g. the TV can become an information displaying monitor at its end of life.

The implementation of a Circular Economy and closed loop supply chain implies changes in customer behavior and preference modifications. In fact, the company must take appropriate care of the rented out TVs during the use phase and timely retract their rented out products to create demand for the purchase and use of refurbished products.

The above cited hardware and software customization options, which integrate the principles of Eco-Design, along with the implementation of a TV configurator, which provides sustainability information to the consumers, allow the company to directly promote the "Sustainable Solution Space Development" and the "Sustainable Configuration" SMC patterns. The latter implies a stronger focus on long term relationships with customers based on sustainability improvements, consumer Awareness and ethical consumption.

In contrast, the implementation of the "Product Stewardship" and the "Additional Services" SMC patterns also require the development of new services and the involvement of a large number of actors belonging to the consumer electronics supply chain (manufacturers, retailers, refurbishment plants, etc.). Despite the highly disruptive potential of such SMC patterns, both in terms of MC and sustainability, their current applicability is hindered by the required but not prevailing high degree of involvement of retailers and manufacturers in the product rental system and by the complexity of the upgrade and reuse options as well as the closed loop value chain.

6. DISCUSSION AND CONCLUSION

The proposed framework for the development of SMC business models allows to better understand the links between MC and sustainability and to better plan the strategies to achieve both objectives. This framework contains seven generic SMC patterns that serve as building blocks for entire SMC business models. Most of the SMC patterns are complementary but it is difficult to discriminate among them from an application point of view. Companies can use these generic patterns as a construction kit in order to develop a concrete and

company-specific SMC business model. The application in the TV industry provides some interesting findings. A structured and formalized description of the various SMC enablers were extremely valuable to the multidisciplinary team involved in product design that helped to elicit the interdependencies among the various enablers and to correctly set the priorities for the development of suitable SMC patterns from a strategic and operational point of view.

The development of our framework for SMC business models is entirely based on literature and the qualitative assessment of academics and experts in the TV industry. A broader empirical application of the proposed framework is fundamental to validate the established links among the SMC enablers and to understand how supply chain and product characteristics influence the nature of the most suitable SMC pattern. Therefore, scholars in the field of MC research are encouraged to carry out empirical validation studies on single patterns, combinations of patterns, and entire business models within different industry sectors. Considering contextual factors for the implementation of SMC [49] and their influence on the various patterns could enrich the proposed framework and lead to valuable refinements.

The framework can be extended by providing additional information about the required resources and other types of constraints. As exemplified in the previous section, the implementation of new services implies significant changes in consumer behavior and revenue stream generation. It also implies the management of the whole product life cycle and a strong coordination among various business actors. It is consequently much more complex and riskier than the introduction of hardware and software customization.

Despite the need for future validation, this study serves as a valuable guide for practitioners to identify suitable starting points for modifying existing business models and moving towards SMC. For academics, the framework serves as an overview and a basis for further investigations in the entire context of SMC.

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Projektovanje poslovnih modela za održivu kastomizovanu industrijsku proizvodnju

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Apstrakt

U poslednje tri decenije se u literaturi u oblasti menadžmenta veoma često diskutuje o ideji kastomizovane industrijske proizvodnje kao poslovnom modelu za kompanije koje nude proizvode korisnicima sa heterogenim potrebama. U isto vreme i diskusija o poslovnim modelima koji se bave povećanom potražnjom potrošača za održivim proizvodima dobija na značaju. U oblasti kastomizovane industrijske proizvodnje postoji nedostatak istraživanja koja uzimaju u obzir održivost poslovnih modela zasnovanih na kastomizovanoj industrijskoj proizvodnji. Ovaj rad doprinosi istraživačkom jazu razvojem niza generičkih šablona održivih poslovnih modela zasnovanih na kastomizovanoj industrijskoj proizvodnji. U tu svrhu, prvo posebno opisujemo prilaze i strategije koje pozitivno utiču na kastomizovanu industrijsku proizvodnju, a zatim na održivost životne sredine. Nakon toga kombinujemo oba viđenja i predlažemo sedam generičkih šablona koji mogu služiti kao vodič za integrisanje održive kastomizovane industrijske proizvodnje na nivou poslovnog modela. Na kraju predstavljamo primenu našeg konceptualnog okvira u elektronskoj industriji, koja prikazuje ideju za njegovu praktičnu primenu.

Ključne reči: *Poslovni model, predlog konceptualnog okvira, kastomizovana industrijska proizvodnja, održivost*

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