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Are modular and customizable smartphones the future, or doomed to fail? A case study on the introduction of sustainable consumer electronics

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ABSTRACT

Mass Customization (MC) has become a major trend in the consumer goods market in recent years. While the economic chances and threats are already described very well, the social and environmental impact of MC products remain unclear. Phonebloks, a design study of a modular smartphone launched in 2013, created a vision about fostering sustainability through MC. Teaming up with Google's Project Ara, a modular and customizable smartphone approach seemed very likely to reach market maturity. In 2016, Google canceled Project Ara shortly before the awaited market introduction. Analyzing the rise and fall of the first large scale MC based business model that was initially designed to foster sustainability in the consumer electronics market, gives us the opportunity to revise the economic, social and ecologic potential of modular and customizable smartphones in general. Furthermore, with constantly growing consumer requirements for new product iterations in shorter time frames, traditional measures for success, such as time-to-market, could change inherently as we are moving closer towards iterative product development processes and much shorter product life-cycles. This, in turn, leads to major changes for ramp-up processes. Using a qualitative case study approach based on expert interviews at two different stages of the Project Ara development process (2015 and 2017), we shed light on the future of modular and customizable smartphones and their economic, social and ecologic sustainability potential. We show that while Project Ara failed in the end, it had the economic potential to outperform its competitors in the field of modular smartphones. We find that an MC approach could lead to longer smartphone or, at least, component life cycles. Finally, we affirm a positive potential for influencing sociocultural behavior in the long tail of the smartphone market.

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Introduction

Mass Customization (MC) has become a major trend in the consumer goods market in recent years. In academia, it has been broadly discussed as a business model to serve customers with heterogeneous needs with individual products and services, both efficiently and effectively [1,2]. While the economic opportunities and challenges have received much attention in research, the ecologic and social perspective of MC is still a rather untapped field of research: whether or not MC can help to overcome unsustainability is still unclear [3].

Phonebloks, a design study by Dave Hakkens that has been watched more than 20 million times on YouTube since 2013, initiated a broad discussion in the public realm on successfully linking MC with sustainability in the consumer electronics market [4]. When Phonebloks teamed up with Google's Project Ara, a modular and customizable smartphone approach was expected to reach market maturity [5]. For researchers, following the new product development process and the introduction of an MC business model that aimed at fostering sustainability, and studying the corresponding ramp-up phase were seen as an exciting opportunity to assess MC from a sustainability point of view (see Ref. [6] for the initial study our paper at hand builds upon). Does the idea of introducing a modular and customizable smartphone have the potential to reduce the environmental impact of consumer electronics? Is it possible to scale up a complex

customer-centric and multi-stakeholder involving concept like Project Ara, while fulfilling the economic, social and environmental expectations at the same time?

Two years after announcing Project Ara, Google canceled the long awaited introduction of the first large commercial launch of a modular and customizable smartphone [7]. The cancellation raises two supplementary questions, which we target in this study: First, did the existing concepts fail to scale up due to technological, socio-economic or organizational challenges before ramp-up? Second, are concepts of modular and customizable smartphones generally doomed to fail or what must be learned from Google's drop-out from a sustainable modular and customizable smartphone development perspective in the future?

To answer our research questions, we use a qualitative research design. First, we reviewed secondary data including webpages related to relevant modular and customizable smartphone concepts, especially those of Project Ara and Phonebloks, videos and other materials from development conferences, twitter accounts, and newspaper articles. Second, we conducted and evaluated two rounds of semi-structured interviews with experts sharing their distinct perspectives on modular and customizable smartphones, six interviews preceding and eight following Ara's cancellation. In the second round, not only the founder of Phonebloks shared his particular view on Project Ara with us again, but also two leading employees at Fairphone provided us with their very specific insights into their own journey towards modular smartphones.

Our study is structured as follows: First, we give a theoretical introduction to the general concept of MC, to the current state of research on sustainable MC, and to the concept of ramp-up. In a second step, we introduce the modular smartphone case and explain our research methodology. In a third step, we discuss the case study in a four-stage process: (1) modular and customizable smartphone business models, (2) environmental sustainability potential, (3) social sustainability potential, and (4) ramp-up challenges. Finally, we provide a summary of the case study's key findings, its limitations and further research opportunities.

Theoretical foundations

Mass Customization and modularity

"Developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want" [8] is how Joseph Pine – as one of the first, who made the term popular – defined MC. The two factors, which MC combines, are low costs of mass production and flexibility of customization according to individual needs. MC aims at meeting the individual needs of the customer with products and services that achieve near mass production efficiency [9]. Especially the rapid growth within the information technology sector, which reduces the gap between customers and manufacturers, allows the evolution of MC [10]. MC companies do not treat customers as simple product buyers, but actively integrate them in the product design process and in following development cycles [11].

Modularity, an essential element of any MC strategy [12], is an approach that implies the composability of the final product from a set of standardized components. By integrating different sets of such standardized components, a large variety of different outputs can be realized [13]. The effort to change components in a modular product architecture is smaller compared to an integrated product design, due to the possibility of exchanging single parts and not necessarily the whole product for a change in functionality or performance [14].

In particular, four different modularity approaches play a role within MC: (1) generic, (2) quantitative, (3) individual, and (4) open modularization. While generic modularization allows the addition of a fixed number of standardized modules with different technical specifications to a basic module, the quantitative approach enables a variation of the amount of additional modules to the basic one. During individual modularization, customers still have to rely on the basic module, but have the possibility to add customized ones. Finally, the basic module becomes obsolete with open modularization, due to the possibility to connect separate standardized or customized modules directly to each other [15].

Sustainable Mass Customization

Dave Hakken's idea of using MC for making consumer electronics more sustainable corresponds to a rather untapped area in the MC field of research. Until today, both conceptual and empirical research on how MC contributes to the paradigm of sustainability is very limited [16,17].

The majority of existing studies are conceptual. Hora et al. [18] theoretically derive a set of generic sustainable MC business model patterns. Two of these patterns are directly linked to the modularity aspect of MC. Other existing studies mostly address issues of MC that either relate to a whole product life cycle approach or to specific stages in order to explore the effects of MC on sustainability. Pourabdollahian et al. [16] point out several impact factors of MC on sustainability in all stages of the product life cycle. Although building on the triple bottom line concept of sustainability [19], the study mainly focuses on environmental impact factors. Nevertheless, the study points out that there often is a relation between the social and environmental dimension. In a similar, but more general approach, Brunø et al. [20] conclude that the balance between positive and negative impact factors highly depends on the specific market characteristics. In general, sustainability assessment of MC is very complex, and requires a lifecycle based supply chain management perspective [21].

Among these studies examining the earlier stages of the life cycle, Hankammer et al. [22] and Trentin et al. [23] mention the potential of sales configurators to create awareness and promote more sustainable choices. Badurdeen and Liyanage [24] as well as Kohtala [25] point out the importance of the co-design process as a whole as a means to move further towards sustainability. At the end-of-life stage, current research emphasizes the shift from open-loop to closed-loop life cycles and, thus, the creation of multiple life-cycles [26,16,17]. In this context, several streams of research propose that product service systems and corresponding changes in ownership are complementary strategies for sustainable MC [24,27,22,18].

For assessing modular and customizable smartphones from a sustainability perspective, we build on the existing research on sustainable MC. For our case study, the question of longevity is most relevant [28,29]. Following the triple bottom line concept of sustainability [19], the assessment of modular and customizable smartphones should also take the social changes, initiated by the introduction of a modular and customizable smartphone concept, into account. This includes the assessment of "the impacts of products and services on people" [30] and the consequences of modular and customizable smartphones on the interaction between the infrastructural, technological, economical and socio-cultural parts of the system [31].

Ramp-up management and new product development

New product development (NPD) is a vital factor for firms to generate profit and growth [32]. NPD delineates the process of a product's market introduction. It therefore spans the whole period