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A creativity-driven Case-Based Reasoning Approach for the systematic Engineering of Sustainable Business Models

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Abstract

While traditional business models pursue mainly monetary interests, sustainable business models make a contribution to face the ecological and social challenges of our time in an economic way. Companies - especially SMEs - are often faced with the challenge of developing sustainable business models. Typically, new business models often represent a recombination of already known business model patterns. In this paper we introduce a creativity-driven case-based reasoning approach to support companies in innovating business models towards sustainability in a systematic and creative way. Therefore, we combine different methods of business model engineering as well as innovation and exemplarily apply the resulting methodology.

Keywords: Case-Based Reasoning; Business Model Development; Business Model Innovation; Sustainable Business Models; Decision Support System; SME

1. Introduction

Increasing challenges in the field of sustainability, such as rising global resource consumption [1], growing social inequality [2], or accelerating climate change [3], make sustainable economic systems increasingly necessary and in parallel attractive [4]. In this context, “Life cycle engineering (LCE) is a promising choice to achieve sustainability due to its long-term perspective and consideration of both economic and ecological targets” [5]. Since ecological well-being is the basis for the growth of societies and economies, increased attention must be paid to the environment [6]. However, sustainable business models (SBMs) are part of LCE since they have the potential to address environmental and social challenges in an economic way [7, 8]. In general, a business model (BM) describes the way a company creates and delivers value to the customer and generates revenue for the company [9–11]. Sustainability in the business context expands the definition of BMs in terms of also achieving social and environmental benefits. In addition to the conventional elements of a BM, the exchange relationships in a SBM with all relevant stakeholders, including customers, must be considered [12, 13]. Due to the multidimensional nature of sustainability, developing a SBM that takes into account ecological, social, and business aspects is challenging and often leads to uncertainties and value conflicts [14]. However, companies, especially small and medium-sized enterprises (SMEs), are faced with the challenge of transforming classic BMs into SBMs [15]. In 2019, 99.3% of all German enterprises (excluding agriculture, forestry, and fisheries) and with turnover from goods and services and/or employees were SMEs [16]. Due to the resulting presence, SMEs play a central role in the age of globalisation, both in sustainable development in industrialized and developing countries [17]. Managers must regularly question their own BM and repeatedly make different decisions about the design and further development or engineering of BMs [18]. Here, the engineering of a BM refers to the systematic creation or modification of BMs [19]. As part of the engineering process, business model innovation (BMI) is used helping the company to anchor sustainable solutions on the one hand and to be more

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resilient to competitors and to achieve higher returns on the other hand [4, 7]. In the past, several scientific proposals have been presented to support SMEs with this challenge [15, 20, 21]. Canvas methods such as the Business Model Canvas (BMC) by Osterwalder and Pigneur 2010 [10] are widespread for the innovation and engineering of new BMs in many companies [22, 23]. However, it is not always necessary to create new BMs. Elements from existing BMs can be used to develop further BMs [24]. With the advent of decision support systems new possibilities for BMI arise [18]. Such a decision support system can be found in the case-based reasoning (CBR) approach which solves problems based on previous, similar cases [25].

The overall research question is of how SMEs with their special requirements and challenges can be effectively supported in systematically engineer SBMs in a creative way without disturbing their normal behaviour in BMI. Therefore, we propose a decision support system based on a special form of a CBR approach, using the Curiosity Cycle. To ensure that the BMI is sustainable, an evaluation for sustainability, especially geared to SME is integrated. With the help of our approach, companies should be supported in the finding of innovative ideas for the transformation of classic BMs into SBMs, as well as helping already sustainable companies to make their BM more sustainable. To this end, the requirements of innovation seeking companies are analysed in chapter 2. Furthermore, the state of research in the field of SBMs is presented. This builds the basis for chapter 3, where we introduce our CBR-approach to support the development of SBMs in a creative way. The approach is applied in an exemplary use case in chapter 4, while chapter 5 concludes the paper and presents a brief outlook.

2. State of Research

Most research has mainly focused on the investigation of BMI in large enterprises, instead of focusing on SMEs [26]. Recent research shows that SMEs are willing to improve their BMs but BMI in SMEs is still relatively unknown [26]. However, due to their potentially limited knowledge in environmental sustainability, SMEs may not be able to contribute expertise to develop or innovate their BMs into SBMs [15, 27]. For a successful BMI, SMEs should think outside the box, experiment with new BM concepts, generate new ideas and use BM methods and tools [28, 29]. Usually, new elements are added to the existing BM [30]. Many SMEs (approx. 30%) merely adapt and internalize innovative ideas and technological solutions from others without experimenting themselves [23, 31]. The main requirements of a support system dedicated to SMEs should therefore be simple to use, generate particularly creative solutions and support the behaviour of SMEs in the field of BMI by adapting BM elements from others while incorporating sustainability requirements. Concluding, SMEs should undergo a systematic engineering process for SBMs while incorporating a sense of creativity. Against this background, common approaches for the engineering of SBMs are reviewed in the following. Therefore, canvas-based and CBR approaches are considered in more detail, forming the basis for the design of the proposed methodology.

2.1. Conventional, canvas-based approaches to developing sustainable business models

Numerous approaches to support the engineering of (S)BMs have been developed in recent years [32]. Based on the common BMC, many different Sustainable Business Model Canvases have been further developed. Each of these canvases brings in other aspects of sustainability that have not been considered so far. In addition to the Flourishing Canvas by Fath-Kolmes 2018 [33], the Triple-Layer-Business-Model-Canvas by Joyce and Paquin 2016 [34] and the Value Mapping Method by Bocken et al. 2013 [35] are well-known approaches in literature. To effectively support SMEs with BMI, more simple approaches with a clear reference to their needs are required [36]. The before mentioned canvases are of high complexity and may therefore not be suitable for SMEs. One approach that fulfils this requirement is the Sustainable Business Canvas by Tiemann and Fichter 2016 [37]. It is based on the BMC and provides an integrated approach towards sustainability. It supplements the BMC not only with the categories ‘vision & mission’, ‘competitor’ and ‘other relevant stakeholders’ to reduce complexity. It also combines ‘business segments’, ‘customer relations’ and ‘customer channels’ in the overall category ‘customer’. In addition to the ‘classical leading questions’ of the BMC ‘sustainability-specific leading questions’ are defined. Therefore, a list of questions is supplied with specific questions in each element to guide the approach-user in the completing process. This meets the simplicity requirement of SME by providing a questionnaire that enables even non-specialist users to quickly develop a sustainable concept [37].

2.2. CBR approaches to support the development of sustainable BMs

Based on the challenges SMEs face in the areas of BMI, different types of software-based approaches have been proposed to support BM development processes, such as software supported application of BMC or Value Proposition Canvas Methods [38]. For SMEs, the CBR approach is of particular interest for the engineering of SBMs as it meets the special requirements of SMEs.

The CBR approach is applied when there is no general knowledge about a problem – such as the lack of knowledge about BMI opportunities. In the CBR approach, a problem solution is induced by using already stored knowledge in four phases. This stored knowledge is usually structured in a case base. Problem solving is done by interpreting a new case by searching the case base for similar cases (Retrieve-phase) and suggesting the most similar case as a problem-solving option (Reuse-phase). After that, problem solving is achieved by the adaptation of the proposed solution (Revise-phase). New knowledge in the form of a new case is then created and the knowledge is recorded in the case base so that it is immediately available for solving the next problem (Retain-phase) [39]. In the past, researchers have already used CBR to support BM development and innovation [40–43]. The basic principle is that knowledge from existing BMs is stored by different documentation methods (like the BMC) in order to generate the case base, depending on the approach. Lee et al. [40] combined the principle of the CBR approach with a morphological box consisting of BM building blocks to provide a structured methodology for BM development. Kuntzky [41] used a CBR approach to support the development of Product-Service-Systems. Those systems are promising for achieving sustainable goals in business context [44]. Shao et al. [42] use the CBR approach in combination with the Theory of Inventive Problem Solving (TRIZ) method to drive BMI in a company. Pieroni et al. [43] presented a modular expert system based on the CBR approach to develop circular economy business models (CEBM). Through the four modules 'Identifying CEBM opportunities', 'opportunities designing CEBM alternatives', 'configuring CEBM alternatives' and 'Evaluating potential of CEBM alternatives' the system supports not only idea generation but also, in particular, CEBM design, evaluation, and optimization [43]. With the exception of the holistic approach by Pieroni et al., most approaches are only suitable for the idea generation of a BM [43]. These approaches use the classic CBR principle described above. A fundamental extension of these approaches can be the Curiosity Cycle (CC) by Maher and Grace 2017 [45]. The authors use a surprise effect to stimulate creativity. CBR is embedded there in a concept that provides the user with positively surprising recipe suggestions for meals. This requires a preference and surprise model in addition to the case-based thinking common to the CBR approach. To validate the concept, the authors have already designed and programmed an algorithm so that a practical application could succeed. We are consequently transferring this CC approach to the field of sustainable BM innovation in order to benefit from the surprise effect, following Henry Ford's saying: "If I had asked people what they wanted, they would have said: faster horses".

3. Methodology

Motivated by the need for sustainable BM innovation of SMEs, we introduce a concept that encourages the creative thinking of entrepreneurs while ensuring sustainable development. It is a creative CBR approach that relies on proven solutions from practice concerning both, existing BMs and sustainability measures (see Fig. 1). Instead of the common CBR cycle, the presented iterative CC approach is a novel way for SBM innovation (see section 2.2). The advantages of an iterative CC approach are based on the initial uncertainties in the early development phases and the flexibility required for innovative thinking [46].

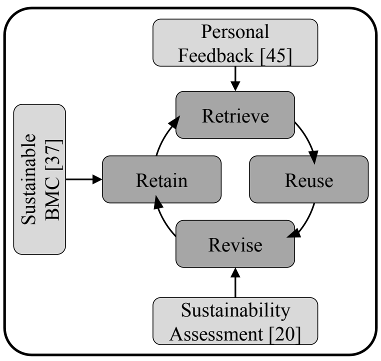

Figure 1: Methodical approach for Sustainable Business Model Innovation

The outcome of the CC approach is a case-specific SBM proposal that initiates a change of perspective through moments of surprise and encourages outside the box thinking. It offers increased potential for entrepreneurial creativity as described by [47], while at the same time pursuing a systematic engineering process. To ensure a sustainable case base, the user's renewed SBM is evaluated and improvement measures are given in terms of sustainability before implementation.

Our concept of a creative CBR approach (see Fig. 2) consists of six phases: 1. Creation of the case base, 2. Determining the scope, 3. Personal user feedback, 4. Matching algorithm, 5. Stimulating creativity and 6. Sustainability improvement. These steps are described in more detail in the following.

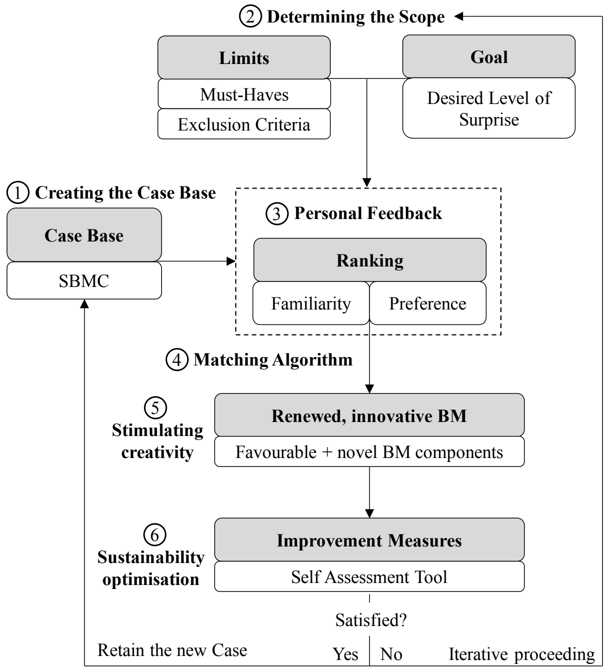

Figure 2: CBR-based approach for Sustainable Business Model Innovation

3.1. Creating the case base

The foundation of the CBR and thus of the CC is the case base. Before the CC can be passed, it is important to fill the case base with an initial number of successful SBM cases from practice (see section 2.2). It contains all information about previous problem solutions and is therefore the data basis on which the retrieve algorithm can rely on [39]. The prerequisite for the retrieve algorithm is the specific characterisation of the problem. Attributes are defined that describe all SBMs contained in the case base as accurately as possible. One possibility to describe all attributes of a SBM is using a canvas method as described in section 2.1. In the proposed CC concept the Sustainable Business Canvas by Tiemann and Fichter [37] is chosen to build the structure of the case base due to its user-friendly design that ensures a holistic understanding over the whole lifecycle without exceeding complexity.

3.2. Determining the scope

Determining a scope for the SBM is the first step, which the user must actively decide on. Here, limits are set by defining both exclusion criteria and must-have elements of the SBM. This ensures that the result is applicable to the user's situation. To illustrate that, a useful must-have element would be the sector in which the company wants to operate, and an exclusion criterion could be a financial investment that extends the budget. To ensure the surprise effect of the results, it is important that these hard limits are set as broadly as possible, so that on the one hand the implementation of the SBM can still be ensured and on the other hand creativity is stimulated as much as possible. Additionally, deciding on the desired level of surprise is an essential part of determining the scope. Any level of surprise between 0% (only SBM elements in which the user is already an expert are proposed) and 100% (every aspect of the outcome is completely unknown to the user) is possible. Here, it has to be evaluated individually for which purpose the CC is used. However, it usually makes sense to choose a value beyond both extremes.

3.3. Personal user feedback

In addition to the previously determined scope, comprehensive user feedback is needed in the next step. The feedback creates two models that contribute to the final result: The familiarity model (A) and the preference model (B). These were developed by Maher and Grace [45] and are applied here to the case of SBM innovation.

A. The familiarity model requires the entrepreneur to assess how confident he is with the proposed SBM elements. This can be done through rankings. The purpose of the familiarity model is that the system learns what SBM elements are novel to the user. Based on this information, the system is able to identify SBM elements that cause a high surprise effect (i.e. a very low level of familiarity).
B. The preference model is created similarly to the familiarity model. This time, the user is asked to classify the SBM elements according to preference. In this sense, preference means a free association in which the user should assess how appealing the proposed SBM element appears. Each element is considered on its own and not evaluated in a strategic context.

It should be pointed out that characteristics which the user is not (yet) familiar with can also attain a high degree of preference.

3.4. Matching algorithm

The matching algorithm now combines the information from the previous steps (must-have elements, exclusion criteria, level of surprise, familiarity ranking, preference ranking). Based on this, the algorithm selects those SBM elements that meet the following requirements: The SBM proposed by the matching algorithm have to (a) stay within the boundaries of the must-have elements and exclusion criteria, (b) include as many ‘surprise elements’ as are required by the defined level of surprise, and (c) maximise the value of preference. This can be achieved by using a score system in the ranking. The algorithm composes SBM elements with values that maximise preference while ensuring the desired level of surprise. Following this, an innovative SBM is proposed that is structured according to the Sustainable Business Canvas.

3.5. Stimulating creativity

When the new SBM is presented to the user it is not the goal to offer a final solution (in contrast to normal CBR approaches). Rather the entrepreneur himself is asked to think outside the box by suggesting new ideas that match his preferences. The ‘surprise elements’ are central at this point. ‘Surprise elements’ are SBM elements that have a very low value in the familiarity ranking but at the same time are highly preferred by the user. These can be e.g. SBM elements from different branches. It is beneficial for stimulating creativity to propose few, but therefore completely new SBM elements. Selecting many moderately known elements instead stimulates creative thinking less strongly [45]. Now the entrepreneur adapts the proposed SBM individually (see Revise-phase at CBR) through stimulated innovative creativity.

3.6. Sustainability improvement

If the only aim was to support the innovation of SBMs, the user could now decide whether to accept the result or to gain another perspective by running the CC again. However, since there is a need to promote SBMs for SMEs (see chapter 2), we extend the CC according to Maher and Grace [45] with an approach that enables sustainability improvement. This ensures that the case base is increasingly filled with SBMs and gives already sustainable SBMs the chance to identify further improvement potential. The “holistic and rapid sustainability assessment tool for manufacturing SMEs” [20] is a self-assessment tool for manufacturing SMEs that has been tested in research and practice. When the CC user is satisfied with the new SBM and has made specifications to implement it in practice, the assessment tool suggests further improvement measures to increase its sustainability performance. The user can therefore make new adjustments to meet the improvement potential.
The outcome of the CC is therefore as follows: Users who want to innovate their business models and improve their sustainability performance provide information about personal preferences and expertise. Based on this, the matching algorithm proposes a new SBM with elements of surprise. To ensure that the SBM is sustainable, a sustainability improvement is carried out. If the user is satisfied with the final solution, the new practical and sustainable case is retained in the case base to enable future users to generate ideas from it. If not, a new iteration cycle can be started.

4. Application of the methodology

To demonstrate the application of the CC-based approach, it will be applied using an e-bike producer as an exemplary example. The original business model of the producer is based on assembling the supplied parts of the bicycles and selling them through local retailers. It is assumed that the case base is filled.
In order to innovate the BM of the e-bike producer by means of the CC, the producer first determines that his core product

should remain the e-bike (must-have element) and that he is not interested in taking over the manufacturing process of the parts himself (exclusion criteria). Since he is open to new perspectives and suggestions but without completely reinventing his BM, he determines a level of surprise of 30%.

This information sets the scope for the matching algorithm. For the matching algorithm itself, it is important to analyse which SBM elements are familiar to the e-bike producer and, furthermore, which preferences the user has.

For this purpose, SBM elements are proposed to the producer that are within the previously defined scope. Thus, ranking the preferences and familiarity of e.g. 'Value Proposition' there is no proposal of SBM elements that state producing a different product than an e-bike. Looking at the category of 'key partnerships' the following examples could be suggested: 'manufacturers', 'public entities', 'retailers', 'travel agencies' and 'logisticians'. The e-bike producer then needs to assign two values to these suggestions. Firstly, how familiar he is with the cooperation with those partners and secondly, how well he would welcome (potential) cooperation. In this example, this is done with a ranking from 1 (very high preference/very high level of familiarity) to 5 (very low preference/very low level of familiarity). Partners who are essential to his core business (e.g. manufacturers) receive a 1 or 2 in both categories. However, it is also possible for well-established partners (e.g. retailers) to receive a good familiarity score but a low preference. This is the case e.g. if the partners proved to be unreliable in the past or if the e-bike producer wants to try out different sales opportunities. Based on the existing business model stored in the case base, the producer knows which cost and revenue categories he can expect. Of further interest are those elements that are unknown to the e-bike producer (e.g. cooperation with travel agencies) but seem favourable.

This ranking is done with elements concerning all categories of the Sustainable Business Canvas and then entered into the system. The matching algorithm now integrates the collected information in order to make an optimal selection. The familiarity values should be selected so that they have an average score of at least 1.5 (30% level of surprise from 5 as the maximum value). This means that the proposed SBM consists mostly of known SBM elements, supplemented by some strongly unknown ones. The preference value must be maximised (aim for a value of 1). The unfamiliar elements in the SBM can be spread across all Sustainable Business Canvas categories, thus creating a surprise effect. For example, the e-bike producer could be encouraged to partner with travel agencies that would then provide their customers with e-bikes from the producer's company for the duration of their holiday. Now the e-bike producer specifies and creatively adapts the innovative SBM so it can be implemented in practice (e.g. searches for specific travel agencies to cooperate with). To ensure that the new SBM is designed in terms of sustainability it is checked with the tool by Chen et al. 2014 [20]. Here, for example, the suggestion can be given to avoid long transport routes, so the producer decides to cooperate with local travel agencies. Once the sustainability optimisation has been completed and the SBM is in its final state, it is transferred to the case base as a new case. In this way, future users can benefit from the ideas of the e-bike producer and the cycle is continuously improved.

5. Conclusion and outlook

With our proposed approach, we make a contribution in the field of LCE, because LCE "[...] aims at providing engineering tools targeted towards cleaner product-oriented activities for improving the environment while contributing to competitiveness and growth" [48]. The CBR-based approach helps SMEs in the development and innovation of SBMs for archiving environmental and social goals in an economic way. In contrast to the common CBR approaches, the CC demonstrates a new, creative approach that on the one hand allows outside-of-the-box thinking and meets the ability to experiment that is required by SMEs. Thus, the maximum possible creative process is given. On the other hand, the proposed sustainable BMI ensures the feasibility based on the old BM and existing competences of the SME by defining the familiarity as well as the preference model. Thereby, the consideration of sustainability requirements is always an integral part of the proposed business model development method. Our CBR-based approach has the advantage of supporting SMEs in BMI without restricting SMEs in their current innovation strategy. This is because the case base consists of implemented solutions from which the SME adapts solution elements from others, as do 30% of SMEs. The fact that the CBR works in the context of BMI has been demonstrated multiple times by previous proposals (see section 2.2). Thus, based on the successfully implemented use case, we assume that the CC approach based on the CBR approach also performs.

In future, we will test our proposed approach by applying a design science approach in order to continuously develop the tool. Another limit exists in relation to the case base: The CBR approach only works with an initial, existing case base, which is continuously expanded through the implementation of new solutions through use. In the beginning, we therefore have to fill the case base ourselves for test reasons. Thus, it requires the implementation of real BM by the user. For this reason, it is necessary to continuously include new SBMs in the case base. This is initially done by analysing existing SBMs, and after implementation and use of the tool, the case base is constantly expanded by users of the tool.

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