The Classification of Sustainable Business Model Patterns using Machine Learning

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Extended abstract

Background and aim

Over the past decade, a significant body of knowledge about the various forms of sustainable business models (SBMs) has emerged (Dentchev et al. 2018; Evans et al. 2017; Lüdeke-Freund & Dembek 2017). This knowledge is distributed across various publications from several domains, such as social and ecological entrepreneurship, innovation and design, and operations research. The available categorisations include typologies (Dohrmann 2015; Tukker 2004), taxonomies (Lai et al. 2006; Lüdeke-Freund et al. 2018b), ideal-types (Stubbs & Cocklin 2008), archetypes (Bocken et al. 2014), and frameworks (Fielt 2013).

Whilst some reviews aim to consolidate the distributed knowledge (e.g., Bocken et al. 2014; Lüdeke-Freund et al. 2018a; Lüdeke-Freund et al. 2019), others face issues with overlapping, inconsistent and incongruent descriptions of SBM types. These inconsistencies result, inter alia, from varying descriptions of the actual unit of analysis, overly inclusive definitions of the business model concept, or mixing up factual and normative foundations of describing existing and potential SBM types. These hamper the development of a common SBM repository and language that can continuously grow and be used across different domains (e.g., innovation, entrepreneurship, accounting, etc.). Such a repository would serve several purposes: researchers could use the identified SBM types as analytical lenses for their theoretical and empirical research (e.g., studying the relationships between certain SBM types and corporate sustainability performance), and practitioners could use this information as a source of inspiration for their business development projects (e.g., as an innovation management tool). Our assumption is that the current lack of clarity about existing SBM types limits our understanding of how and when organizations can make real contributions to sustainable value creation.

Therefore, in this paper, the problem of inconsistent descriptions of SBM types is addressed by combining two approaches: pattern theory (Alexander 1977, 1979) and machine learning (Binkhonain & Zhao 2019). The aim is to develop and apply a method that supports the systematic automated identification and classification of SBM patterns.

Leveraging pattern theory and information systems

Some authors suggest using pattern theory as a framework for the identification, description and systematic categorisation of business models (e.g., Gassmann et al. 2014; Lüdeke-Freund et al. 2018a; Lüdeke-Freund et al. 2018b; Remane et al. 2017). Patterns are mostly derived from experience and empirical observations, and are therefore demonstrated to be proven problem-solution combinations (Leitner 2015). Patterns are instruments to codify knowledge systematically and to transform it from the tacit to the explicit (Lüdeke-Freund et al. 2018b).

Opportunities offered by the increasing sophistication of information systems (IS) in areas such as big data analytics and machine learning (ML) (Melville 2010) can help us to discern patterns in the description of business models as they appear in corporate literature and websites, as well as in official reports such as financial statements and sustainability reports (Michalak et al. 2017; Villiers & Sharma 2017). In the case of multinational enterprises, where the law often requires it, these audited documents are commonly made available publicly online via the web (Szekely & Vom Brocke 2017). Given the magnitude of open data available, an advanced software-based pattern recognition system using ML can help to search, identify and classify textual business model data (Gholami 2016). Developing a tool that can be operationalised through ML places IS at the cornerstone of solving this modern-day challenge, in what is an otherwise difficult transdisciplinary and fragmented field of research (Fielt 2013; Lüdeke-Freund & Dembek 2017), by utilising innovative knowledge to deliver a practical solution. The use of a technology platform powered by extensive IS, allows enterprises to experiment with a range of business models and solutions (Remane et al. 2017). Supported by IS, these platforms can extract patterns, and combinations thereof, thereby discovering trends indicating which business models are conducive to transitioning enterprises to a more sustainable outcome.

Methodology

To ensure the replicability and usefulness (March & Vogus 2010; Pries-Heje et al. 2008; Venable et al. 2012) of the classification tool (identification and categorisation), a design science research approach leveraging knowledge and techniques from IS is adopted (Gregor & Hevner 2013). Initially, seed data may be produced by means of annotation by a field expert or through a data labelling process to produce LABELS, using online glossaries and dictionary of synonyms (Collobert & Weston 2008). Seed data informs the ML process by providing the first-pass information linking TEXT concerned with business models with its associated patterns. The use of ML reduces bias by increasing uniformity and consistency whilst controlling for variance. It also means producing more accurate, scalable, and objective results compared to just using a group of experts. Programmatically, the system may be rerun with various corpus of knowledge to produce more relevant results depending on the purpose of the study (Mehrabi et al. 2019). Management theory resulting from this prescription-driven research approach will be used largely in an instrumental way, to design business model solutions to sustainability entrepreneurship and management problems. IS solutions are considered socio-technical systems contributing to the transdisciplinary design science dialogue (Aken 2004).

Expected findings

By adopting a design science research approach, and by leveraging ML, a set of design principles will emerge as the product of design (Walls et al. 1992) that explicitly augments a class of IS-related problem-solution combinations. The resultant customised, author-developed **S**ystematic **P**attern **R**ecognition **IN**telligent **T**echnology (SPRINT) system (***Figure 1***) processes massive open datasets to classify systematically (i.e., identify and categorise) TEXT (***Figure 2***), ensuring science integrity, repeatability, and increased significance. The SPRINT ML system developed here is a self-replicating construct, which dynamically generates alternatives and removes confirmation bias, thereby benefitting from IS technologies (Lotrian 2019). Data science and big data analytics adds a sophistication in process far above static reporting (Malhotra et al. 2013), with reduced costs for data acquisition, curation, integration, collaboration, analysis, visualisation, exploration, and predictive knowledge (Wang et al. 2016).

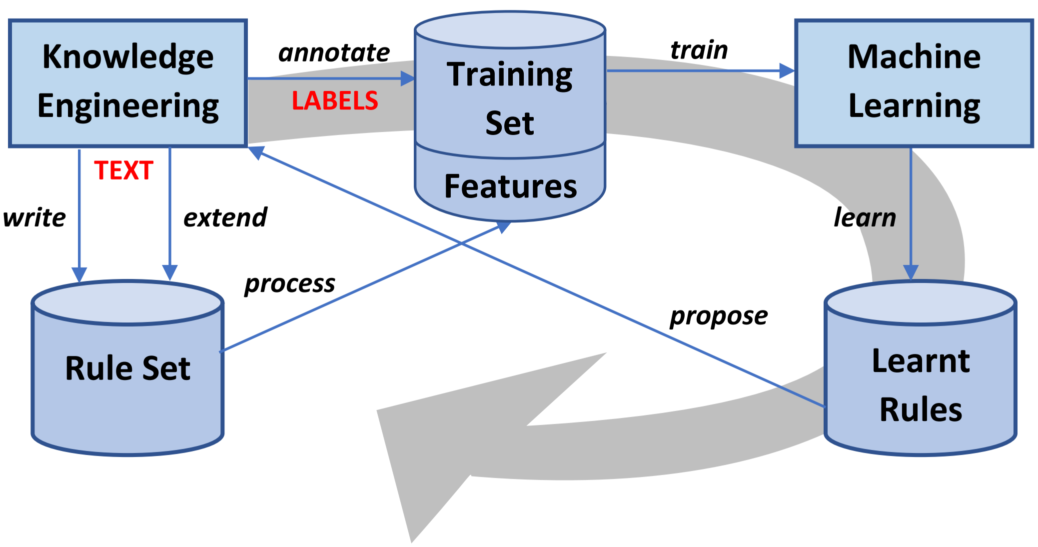

Figure 1. The SPRINT system process model implements machine learning for knowledge engineering.

Enterprises using decision support systems to identify these design principles for IS during business model innovation can support sense-making during their transformation towards business models and activities that are better aligned with sustainability considerations (Seidel et al. 2017). Generated ML models for *Learnt Rules* can be used to produce generalised (Gregor & Jones 2007) grounded technological rules (Aken 2004) for use in the management sciences, and for implementing IS solutions to integrate into an enterprise's sustainability strategy (Cao & Zeng 2019). Classification of SBMs can serve to tackle our urgent problems (Malhotra et al. 2013; Watson et al. 2010) by supporting enterprises transforming towards a more sustainable society (Elliot 2011; Melville 2010).

The SPRINT system

Using source TEXT documents, the ML method LABELS the business model using natural language processing. Accuracy of the seed data determines the reliability of the classification (identification and categorisation) process.

The SPRINT system retrieves the ***TEXT*** from the ***source document (seed data)***,
Then *annotates* with ***LABELS*** to create a ***training set,***
Next, using the ***training set***, it *trains* the ***model [MACHINE LEARNING].***
The SPRINT system *learns* the ***Learnt Rules*** from the ***model***,
By *proposing* the ***Learnt Rules*** to the Knowledge Base ***[KNOWLEDGE ENGINEERING],***
Then *writes* or *extends* rules to the ***Rule Set*** from the Knowledge Base.
The SPRINT system *processes* the ***Rule Set*** to derive ***Features*** (such as weights, frequency, synonyms).

Figure 2. The SPRINT system method.

Conclusions and future research

This study will contribute to an openly accessible and scalable pattern database that aggregates the growing knowledge gained about SBMs (Lüdeke-Freund et al. 2018b). The implementation of natural language processing will be shown to be useful in the transition from static reporting to an ML-based, real-time classification system for SBMs. Given the vastness of the source TEXT publicly available, largely comprised by enterprise sustainability reports, the developed **S**ystematic **P**attern **R**ecognition **IN**telligent **T**echnology (SPRINT) system offers consistency, scalability, and replicability in its identification, categorisation, and classification approach.

By leveraging the strengths of ML, the method proposed here compares favourably with manually performed, one-off reviews (Ritala et al. 2018). Traditional literature reviews can cope only to a certain degree with the exponentially growing SBM field. While these methods are certainly needed to develop topical overviews and theoretical propositions based on *academic works,* ML-based SBM pattern recognition can inform theory from *business practice.* Its automatic nature also allows ongoing and up-do-date overviews. However, this is only a first step. Building robust SBMs also requires the ongoing benchmarking of corporate sustainability performance (Maltz et al. 2018). Future studies ought to evaluate SBM patterns against their true quantitative and qualitative sustainability performance, thus providing a basis of comparison as to which business model patterns are more likely to yield sustainable outcomes.

Aided by big data analytics, ML models, and neural networks for predictive analytics and deep learning, one can expect better predictive capabilities. This in turn will help in identifying which specific business model patterns are associated with certain levels of sustainability, thereby underscoring those business strategies that truly link business model innovation with sustainable development.

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