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Modeling Business Models

A cross-disciplinary Analysis of Business Model Modeling Languages and Directions for Future Research

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Modeling Business Models: A cross-disciplinary Analysis of Business Model Modeling Languages and Directions for Future Research

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Abstract:

Modeling languages for business models are a powerful and flexible means of representing and communicating knowledge related to business models. More than fifteen years after Osterwalder et al. (2005) clarified the ontology for the business model concept in this journal, we offer a systematic and cross-disciplinary assessment of the literature on business model modeling languages (BMMLs) that facilitate the visualization of this concept. In so doing, we synthesize and organize the knowledge dispersed across different disciplines in which BMMLs have originated and highlight the potential weaknesses in this literature to offer solid insights for future research. Our analysis reveals the existence of 17 BMMLs that have originated in traditional domains such as strategy and information systems, but also emerging domains such as sustainability. We contrast and compare these BMMLs along three dimensions: semantics, syntax, and pragmatics. We also analyze research that has made use of these BMMLs, differentiating between research that is conducted with a given BMML and research that is conducted about a given BMML. We conclude by offering a research agenda in which we illustrate the main challenges associated with the lack of well-accepted semantic, syntactic, and pragmatic foundations of BMMLs and outline opportunities for future research.

Keywords: Business Model, Visualization, Modeling Language, Representation, Business Model Innovation.

[Department statements, if appropriate, will be added by the editors. Teaching cases and panel reports will have a statement, which is also added by the editors.]

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1 Introduction

Alongside the emergence and sharpening of the business model concept in recent years, a multiplicity of visualizations on how to represent business models have been proposed. Business models are descriptions of how organizations create, deliver, and capture value for their customers (Teece, 2010). Put differently, business models "describe the business logic of a specific [organization]" (Osterwalder, Pigneur, & Tucci, 2005, p. 3). The innovation of business models has become a decisive success factor for sustaining and expanding the competitiveness of organizations, complementing more traditional dimensions of innovation such as product, process, and organizational innovation (Massa & Tucci, 2014). In this way, business model innovation enables organizations to commercialize emerging technologies, which, in turn, give rise to a variety of new business models (Parvinen, Pöyry, Gustafsson, Laitila, & Rossi, 2020; Teece, 2010). To make the rather abstract descriptions of business models more concrete and more tangible, a plethora of visualizations is available to researchers and practitioners (see Figure 1 for examples of proposed visualizations that represent business models differently; see Appendix A for enlarged figures).

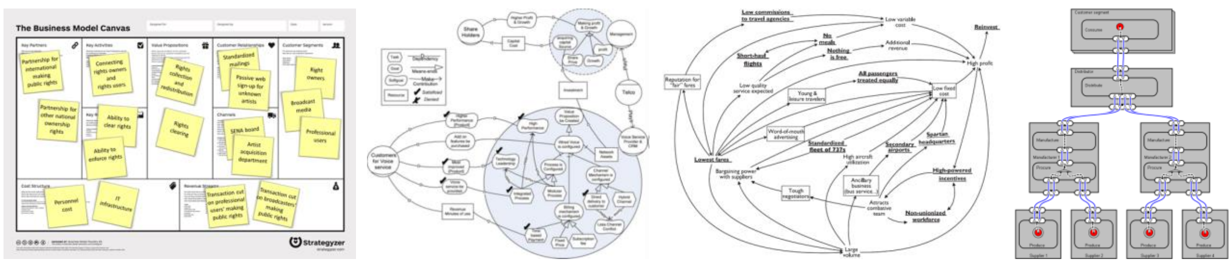

Figure 1. Different ways of visualizing business models

Visualizations in general have been used for thousands of years (Tversky, 2011) and support instruction, comprehension, and discovery (Tversky, 2005). Their importance is widely acknowledged in disciplines as diverse as strategy (e.g., Eppler & Platts, 2009), information systems (IS) (e.g., Wand & Weber, 2002; Bork, Karagiannis, & Pittl, 2020; Avdiji, Elikan, Missonier, & Pigneur, 2020), and computer science (e.g., Jolak et al., 2020). It comes as little surprise, then, that researchers and practitioners have often relied on visualizations to represent business models, emphasizing visualizations' cognitive, communicative, and collaborative merits (e.g., Osterwalder & Pigneur, 2010; Gordijn & Akkermans, 2003; Chesbrough, 2010; Täuscher & Abdelkafi, 2017; Eppler, Hoffmann, & Bresciani, 2011; Eppler & Hoffmann, 2012; Henike, Kamprath, & Hölzle, 2020). What is more surprising, however, is that there has been no cross-disciplinary synthesis, to date, of these widely used visualizations which would allow both researchers and practitioners to understand the similarities and differences between different types of visualizations to make (more) informed decisions when selecting, using, and (further) developing them.

Against this background, we focus on a specific type of visualizations, namely visualizations of the business model that have been proposed with the intent to represent the business models of (m)any organization(s). Differently from *ad hoc visualizations* that are not based on formal rules (see Täuscher & Abdelkafi, 2017 for a review of this type of visualizations) our target visualizations are developed using formal rules (i.e., rules about what is visualized and how), so-called *business model modeling languages* (BMMLs). Modeling languages are a special type of visualization that provide an artificial language that humans can use to express information and knowledge that is defined by a consistent set of rules on the *semantics* (what content or meaning[1] does a modeling language represent?), *syntax* (how does a modeling language represent meaning?), and *pragmatics* (in which context is a modeling language used?) (Burton-Jones, Wand, & Weber, 2009). These rules are used for interpreting the semantics of the core logic and elements of business models. Business models visualized with this set of rules can serve as boundary objects to overcome the knowledge barriers between different communities of practice (Schwarz & Legner, 2020). Therefore, BMMLs are seen as able to facilitate tasks such as understanding, communicating, and innovating business models (Osterwalder et al., 2005), and form an integral part of IS research (Zott, Amit, & Massa, 2011; Osterwalder & Pigneur, 2013; Veit et al., 2014). In addition to that,

[1] In this paper, we follow Burton-Jones et al. (2009), who define the study of semantics as focusing on the meaning of words, phrases, or sentences in a language. We acknowledge that some authors may favor the notion of "content" of a language to refer to the semantic aspect of it.

BMMLs form the basis for researchers and practitioners to develop business model innovation methods (e.g., Bouwman, Faber, Haaker, Kijl, & Reuver, 2008; de Reuver, Bouwman, & Haaker, 2013; Haaker, Bouwman, Janssen, & de Reuver, 2017; Di Valentin, Burkhart, Vanderhaeghen, Werth, & Loos, 2012) and software-based business model development tools (e.g., Athanasopoulou & de Reuver, 2020; Szopinski, Schoormann, John, Knackstedt, & Kundisch, 2020; Ebel, Bretschneider, & Leimeister, 2016; Veit et al., 2014). BMMLs can also support the further maturation and advancement of the business model concept itself, whether, for example, in aiming to make business models measurable (e.g., Montemari, Chiucchi, & Nielsen, 2019; Nielsen et al., 2018) or to integrate business models into legal and financial reporting requirements (e.g., Nielsen & Roslender, 2015; Nielsen et al., 2018). Finally, BMMLs themselves also serve as a starting point for the adaptation (e.g., Zolnowski, Weiß & Böhmann, 2014) and evaluation (e.g., Zolnowski & Böhmann, 2014) of newly derived BMMLs.

Despite the general acknowledgement that BMMLs are important, as of today, the current state of knowledge concerning BMMLs is rather tentative and fragmented. Similarly to the concept of the business model itself and in line with the interdisciplinary character of that concept (Chesbrough & Rosenbloom, 2002), BMMLs have been object of inquiry across a variety of disciplines, including accounting (Sonnenberg, Huemer, Hofreiter, Mayrhofer, & Braccini, 2011), computer science (e.g., Eriksson & Penker, 2000), IS (e.g., Samavi, Yu, & Topaloglou, 2009), and strategy (e.g., Casadesus-Masanell & Ricart, 2010). However, research within and across these disciplines has remained fragmented and often confined to disciplinary silos. This hampers the advancement of research on BMMLs and on visual representations of the business model more in general, because cross-disciplinary integration would allow researchers to draw on the relative strength of each other's discipline. Computer science and IS researchers, for example, have made considerable progress with thoroughly developing and evaluating modeling languages, but their achievements have hardly been recognized in strategy research (Osterwalder & Pigneur, 2013). Strategy researchers, in turn, have highlighted social characteristics of using visual artifacts in the strategy process (Eppler & Platts, 2009), but those aspects have largely been neglected in computer science and IS work on modeling languages (Poels, Burton-Jones, Gemino, Parsons, & Ramesh, 2006).

In summary, researchers and practitioners are left without clear indications concerning the following questions: What do we know about BMMLs and what do we still need to know? For example, what BMMLs exist? How can we compare different BMMLs? What are their similarities and differences? How were they researched so far?

To begin answering these questions, we offer what to the best of our knowledge constitutes the first cross-disciplinary synthesis, organization, and assessment of research on BMMLs (see Figure 2 for this study's research context and focus). More specifically, we focus on synthesizing and identifying research gaps, and on developing a research agenda (Schryen, Wagner, Benlian, & Paré, 2020). Our starting point is a careful analysis of literature focusing on BMMLs. We identify and cross-compare 17 BMMLs that that have originated at different points in time in five domains, notably, strategy, IS, computer science, accounting, and sustainability. These BMMLs differ significantly both within and across disciplines, with little overlap. We reveal and explicate the similarities and differences in terms of semantics, syntax, and pragmatics. Then, aiming to understand how these BMMLs have been adopted, refined, criticized, and/or developed in subsequent research, we identify and systematically review studies that make use of BMMLs. An analysis of this second body of literature reveals that these BMMLs have been used in two main ways. In the first, the BMML is used as a mean to support answering one (or more) research questions. In the second, the BMML itself is the principal subject of investigation. We refer to these two facets as research *with* and research *about* BMMLs, respectively. We identify seven emerging themes, or purposes, capturing the reasons why researchers use BMMLs, and illustrating how they research *with* BMMLs. Furthermore, we identify eight emerging themes illustrating why and how research *about* BMMLs is conducted. Finally, based on an in-depth analysis of both the BMMLs and how they have been applied in research, we derive a research agenda and discuss research gaps, challenges, and paths for advancing the field of BMMLs.

Our cross-disciplinary identification and characterization of existing BMMLs can support practitioners in identifying languages that best possibly fulfill the requirements of a specific context of business model innovation. For researchers, our work provides the foundation for an independent research discipline on modeling languages for business models. We envision such a discipline to be devoted to the cumulative and cross-disciplinary study of visual means for representing business models.

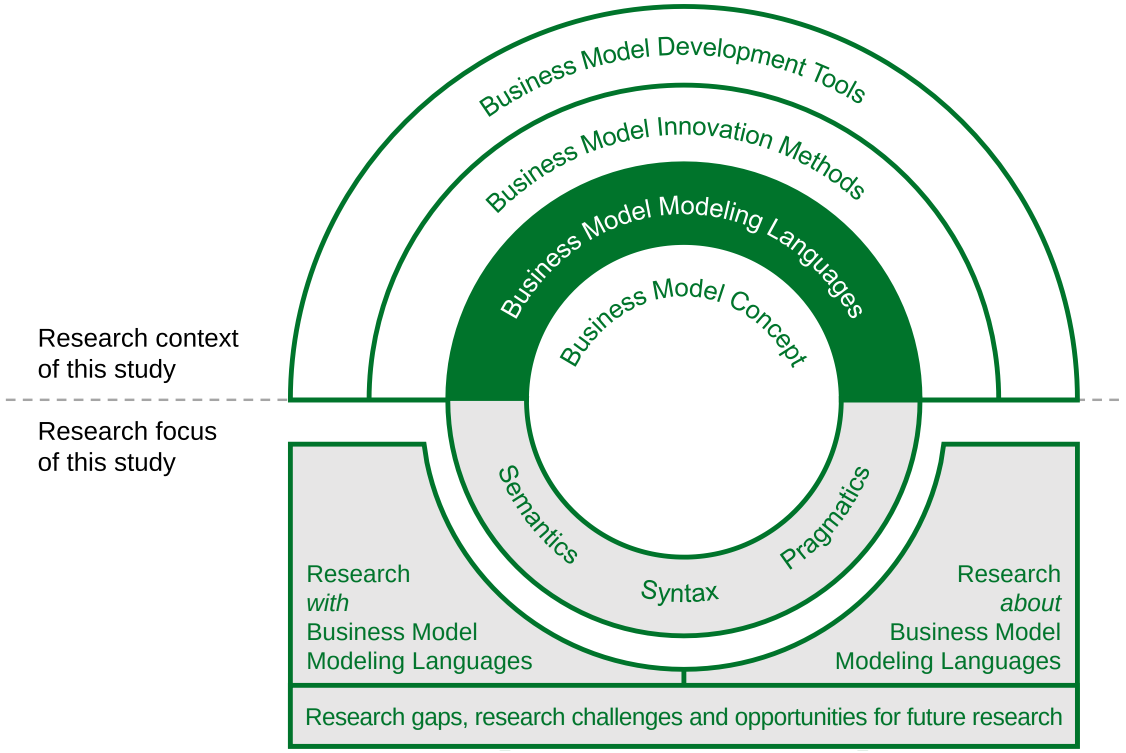

Figure 2. Graphical abstract of this study on Business Model Modeling Languages

2 Background

2.1 Business Models

At a general level, a business model is a "description of an organization and how that organization functions in achieving its goals (e.g., profitability, growth, social impact...)" (Massa et al., 2017, p. 73) or the "design or architecture of the value creation, delivery, and capture mechanisms [that an organization] employs" (Teece, 2010, p. 191). Despite this commonly accepted general understanding, scholars have been struggling to find agreement on more operational definitions of the business model, and how to measure and represent it (e.g., Wirtz, Pistoia, Ullrich, & Göttel, 2016; Massa et al., 2017; Seddon & Freeman, 2004).

According to Massa and colleagues (Massa et al., 2017), one possible source of disagreement stems from the confusion across the literature on the extent to which a business model is akin to a property of a real business, merely a model, or both. They found that scholars have implicitly proposed three conceptually distinct, albeit related, interpretations of the construct, but used the same term, the business model, to refer to them. These are: (1) the business model as a reality existing at the level of the organization, (2) the business model as a *mental* model, that is, an unconscious mental abstraction from reality, and (3) the business model as a *formal* model, that is, a conscious formal abstraction from reality (Massa et al., 2017). We explicitly use here the adjective *formal* to stress the difference with informal or implicit models, namely cognitive schemata, or mental models.

This study is concerned with the third interpretation, i.e., business models as formal models. However, our study suggests that the third interpretation does not in itself represent a homogeneous set. Rather, it is characterized by different *types* of representations. Recognizing the existence of these classes of representations is important. As already briefly described and also further clarified in the following section, we are not interested in all the possible ways in which business models can be represented as some ways offer only limited potential to inform the more general study of visual representations of the business model. By contrast, one of the main intended contributions we want to make with this study is to synthesize, organize, and assess the knowledge on BMMLs across disciplines to lay the foundation for a more integrated study of BMMLs. In the next two sections, we will provide a high-level overview of different types of business model representations, followed by some general insights and guidance concerning the category that we refer to as BMMLs, which constitute the focus of this study.

2.2 Business Model Representations

The question of how to represent business models is not new. Attempts to make sense of the business model through visual representations have been a central preoccupation of business model research from the very beginning.

In an influential review of the business model literature, Zott et al. (2011) have noted—more than 10 years ago—that "several authors have attempted to represent business models through a mixture of informal textual, verbal, and *ad hoc* graphical representations" (p. 8). They offer a section titled "business model representations" in which they synthesize insights from contributions offering visual representations of the business model (e.g., Tapscott, Ticoll, & Lowy, 2000; Osterwalder, 2004; Weill & Vitale, 2001; Afuah & Tucci, 2001).

In this study, and consistent with others (Pateli & Giaglis, 2004; Osterwalder et al., 2005; Baden-Fuller & Morgan, 2010; Doganova & Eyquem-Renault, 2009; Massa & Tucci, 2014; Massa et al., 2017) we understand the term *representation* as comprising both *visual representations* of the business model (e.g., graphical frameworks and/or sketches of business models as in Zott et al., 2011), as well as *verbal representations*, (e.g., a description of the business model created with text). In this perspective, verbal representations are considered as a special type of representation of a business model, which comprises textual elements only, without any graphical elements.

The reason for this purposefully broad conceptualization of the term *representation* is twofold. First, it is consistent with more recent developments in business model research which suggests that descriptions are an important and recurrent way to capture business models and to support business model sense-making or other activities that involve a broad range of cognitive, communicative, and coordinative tasks (e.g., Doganova & Eyquem-Renault, 2009; Perkmann & Spicer, 2010; Baden-Fuller & Morgan, 2010). Second, while verbal representations are clearly distinct from representations that include graphical elements—at least along some dimensions—they nonetheless can be employed for achieving similar goals, such as capturing, "measuring," understanding, and communicating a business model, or supporting idea generation and achieving legitimacy, amongst others. We will explain the purposes of representation in more detail later (see section 4 Business Model Modeling Languages and 5 Research based on Business Model Modeling Languages).

Scholars have approached the problem of representing business models in various ways to pursue different purposes and goals with such representations. For example, according to Magretta (2002), a business model can be captured through a (written) story explaining how an organization functions. Others have explored the use of patterns and archetypes to capture business models (e.g., Abdelkafi, Makhotin, & Posselt, 2013). According to Osterwalder and Pigneur (2010), a business model is best represented by textually describing nine components that are organized visually in a predefined structure, namely, *value proposition*, *customer segments*, *channels* and *relationships*, *key activities*, *partners* and *key resources*, and *cost structure* and *revenue stream(s)*. Casadesus-Masanell and Ricart (2010) suggest that one useful way of representing an existing business model is to see it as the result of the strategic choices operated by management and their consequences, and how choices and their consequences have co-evolved interdependencies. Hence, their representation emphasizes choices and consequences. Others have emphasized, for example, actors and value exchanges (e.g., Gordijn, Akkermans, & van Vliet, 2000; Gordijn & Akkermans, 2003), systems of activities (Zott & Amit, 2010) or business model components, often with only a partial overlap (e.g., Alt & Zimmermann, 2001; Afuah & Tucci, 2001; Morris, Schindehutte, & Allen, 2005; Rayport, Jaworski, de Parres Cárdenas, & Martínez, 2003).

Overall, what do we know about these approaches? How is it possible to compare and evaluate them? Answering questions such as these is a daunting task because many of these representations have been introduced based on the common sense and intuition of the respective author(s). To paraphrase Siau and Rossi (2011), the "blooming" production of business models' representations is not the problem, the lack of standardized rules to develop and evaluate them is. For the (further) development and evaluation of such representations, a more solid basis is therefore needed. This section has provided a high-level overview of some of the possibilities that have been offered by scholars for representing business models. The following section explores in greater depth the BMML category as one very specific type of representation, which is the object of this study, to introduce the reader to the main concepts and the terminology characterizing the notion of modeling languages. Building on these concepts, a definition of BMMLs is introduced.

2.3 Modeling Languages

At a general level, modeling languages employ predefined constructs (such as the notion of an *actor* or a *relationship*) and a visual notation (consisting of, e.g., 1D graphic elements such as lines, and 2D graphic elements such as areas, e.g., Moody, 2009) to represent real-world phenomena in a certain domain (Wand & Weber, 2002). Such modeling languages are used to represent static phenomena (e.g., tangible elements and their properties) as well as dynamic phenomena (e.g., events and processes) (Wand & Weber, 2002). Popular applications include conceptual modeling in general (e.g., Bera, Burton-Jones, & Wand, 2014; Bera et al., 2014; Fettke, 2009; Hadar & Soffer, 2006), process modeling (e.g., Recker, Reijers, & van de Wouw, 2014; Recker, Rosemann, Green, & Indulska, 2011; Recker & Dreiling, 2011), and data modeling (e.g., Parsons & Wand, 2008; Allen, Bajaj, Khatri, Ram, & Siau, 2006; Hitchman, 2003), to mention just a few.

As with natural languages, one can analyze (and develop) different modeling languages depending on, for example, the subject matter to be modeled (in the case of BMMLs, the business model itself), the concept included in the language, and the grammar used to relate the concept or the formal rules that confer meaning to those concept/relationship combinations.

Burton-Jones et al. (2009) have suggested that modeling languages can be analyzed along three main dimensions, namely (1) semantics (i.e., meaning), (2) syntax (i.e., visual form and visual notation), and (3) pragmatics (i.e., use context) (Burton-Jones et al., 2009). The semantics of a modeling language refers to *what* a language seeks to represent (i.e., the “vocabulary” or the set of semantic constructs of a language; Moody, 2009). Syntax refers to *how* a language represents the semantics; that is, which kind of visual form it takes (the architectural form of a representation, such as spatially placed boxes or nodes and arrows) and which kind of visual notation it employs (the type of graphical symbols used, such as arrows, dotted lines, boxes, circles, etc.).[2] The pragmatics of a modeling language refers to the conditions that a language is used in, both its main purpose (e.g., to promote understanding or generate and communicate business model ideas) and its boundary conditions (e.g., the experience of the user with the domain being represented) (Burton-Jones et al., 2009). We will make use of the notions of semantics, syntax, and pragmatics as an organizing principle for contrasting and comparing the different modeling languages that have been proposed for formally modeling business models. We define a modeling language for representing business models as an approach that employs semantic constructs, visual form, and visual notation to represent the business model of a given organization (but not tied to any specific organization) for one or more purposes and through a consistent set of rules.

In the following section, we illustrate how BMMLs were identified, as well as subsequent research based on these BMMLs. The output of this process is the body of work that we used as the basis for the assessment offered in this study.

3 Method

We identified the papers relevant to our review in two stages. First, we identified original sources that propose BMMLs. Second, we identified research that uses BMMLs that were proposed in the original sources.

3.1 Identification of Original Papers

In Stage 1, we sought to identify publications that propose BMMLs. Like others (e.g., Zott et al., 2011), we included both peer-reviewed academic papers and contributions published in books. Books are not surprising considering the roots of the business model discussion in practice (e.g., Timmers, 1998; Teece, 2010) and the influence that some of these contributions have had on subsequent academic research (Eckhardt, 2014). Overall, we included contributions (1) that were explicitly intended by the respective authors to provide a way for representing several different business models (as opposed to a specific

[2] Please note that we subsume the *visual form* and *visual notation* of a BMML as *syntax* for the remainder of this study. When explicitly referring only to the visual form or only to the visual notation of a BMML, we use the more specific terms instead of syntax.

one);[3] (2) that allow representing the business model comprehensively (as opposed to partially); and (3) that adopt a firm-level perspective, i.e., a unit of analysis centered around a focal organization (as opposed, for example, to an industry-level perspective). For identifying relevant contributions, we followed a multistep approach (e.g., Zott et al., 2011; Reim, Parida, & Örtqvist, 2015) (see Figure 3, which describes the three steps that represent Stage 1).

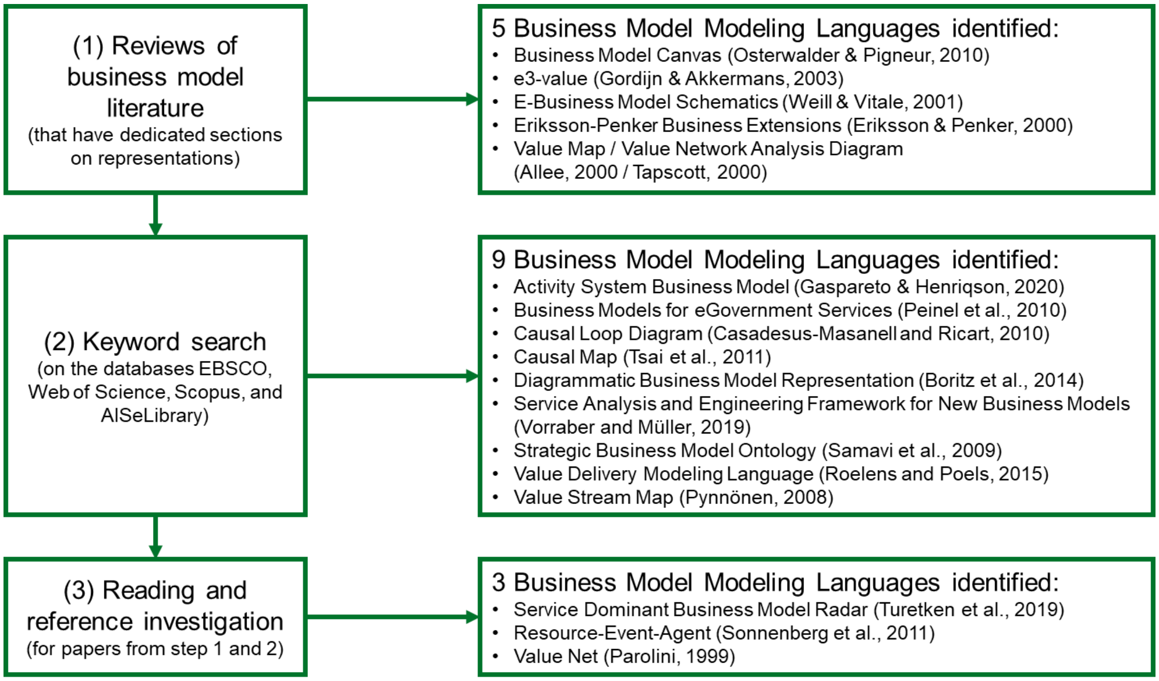

Figure 3. Multi-step process for identification of Business Model Modeling Languages

As the first step of Stage 1, we relied on reviews of the business model literature that have dedicated sections on representing business models (Pateli & Giaglis, 2004; Zott et al., 2011). This yielded five relevant contributions.

As a second step, we performed a keyword search on four databases. To begin with, we searched for journal papers in three databases, namely EBSCO, Web of Science, and Scopus, thus offering comprehensive coverage of the most relevant databases for scientific publications in the field of management and adjacent fields. Moreover, we searched the AIS eLibrary for conference papers and restricted the search to the proceedings of ICIS, AMCIS, PACIS, ECIS, and HICSS, as these represent some of the most important conferences in the IS field. We searched for papers between 1995, the year in which research on business models became prevalent (e.g., Massa et al., 2017; Zott et al., 2011), and 2020. We searched for the term “business model” in combination with various terms that indicate the presence of a modeling language. These terms included the term “visual” and several synonyms as well as terms used to refer to BMMLs in prior research (i.e., “map”, Chesbrough, 2010; “representation”, Zott et al., 2011; “modeling framework” and “modeling method”, Samavi et al., 2009). We searched for these terms in the titles, abstracts, and keywords, using both the singular and plural forms of the terms as well as the American and the British spelling of the word “modeling.” The resulting query yielded 1,333 unique papers (1,288 journal papers and 45 conference papers).[4] As a result of reading all the papers’ abstracts, we identified an additional nine papers proposing BMMLs that fulfill the criteria outlined above.

As a third step, we read the papers in full, paying particular attention to the references these papers make to other potentially relevant contributions. In so doing, we became aware of three additional relevant contributions. The first one is the *Value Net* (Parolini, 1999) which, again, was originally offered in a book

[3] For example, the *Business Model Canvas* was originally conceived to represent many business models and thereby offers an answer to the question of how to visualize the business model concept. In the words of the authors, the *Business Model Canvas* offers “a shared language for describing, visualizing, assessing, and changing business models” (Osterwalder & Pigneur, 2010, p. 12).

[4] The keyword search on the databases EBSCO, Web of Science, and Scopus resulted in a total of 1,836 journal papers. Of these, 548 papers are available in more than one database. We removed these duplicates, which resulted in 1,288 different papers.

but without explicit reference to the term "business model." The second one is the *Resource-Event-Agent — Domain Specific Language* (REA-DSL) (Sonnenberg et al., 2011). The third one is the *Service Dominant Business Model Radar* (Turetken, Grefen, Gilsing, & Adali, 2019). Altogether, our multistep process generated a set of 17 different BMMLs.

3.2 Identification of Citations

Apart from a comprehensive assessment of the literature on BMMLs, we also offer an analysis of how these BMMLs have been adopted, refined, and/or developed in subsequent research. Thus, in Stage 2 we sought to identify papers that cite at least one of the 17 original languages (henceforth: *citations*). For this, we identified citations in journals and books as well as citations in IS conference proceedings.

We used Google Scholar to search for papers citing our identified 17 languages, because Google Scholar allows tracing book citations. The search returned 21,933 results. The comprehensive coverage offered by this database entailed not only advantages (a very large sample of citations) but also some disadvantages: the lack of transparency concerning its data sources, a large amount of lower quality results, and limited functionality for refining search results (Winter, Zadpoor, & Dodou, 2014; Harzing & Alakangas, 2016). To mitigate the latter, we devised the following approach (for details, see Appendix B): We discarded non-English and, in this step, non-journal papers (resulting in 3,913 citations) and subsequently applied Jahangirian et al.'s (2011) method for reviewing a large volume of literature. The method suggests selecting a sample of the relevant literature based on three criteria, namely: citation count (so as not to miss the most frequently cited papers, which are likely to be highly relevant), publication year (to counter the bias against more recent papers that the citation count criterion introduces), and random selection (to alleviate remaining biases). Based on these three criteria, we selected a sample of 746 citations from the 3,913 citations.

In addition, we searched for citations in the proceedings of five leading IS conferences, namely ICIS, AMCIS, PACIS, ECIS, and HICSS. We again used Google Scholar to search for papers citing our identified 17 languages.[5] Unlike academic databases, Google Scholar does not guarantee completeness. Therefore, we matched and augmented the result of the Google Scholar citation search with the result of a complementary search in the AIS eLibrary. The AIS eLibrary does not provide a citation search, but fully covers the chosen IS conferences. This search returned a total of 354 citations. Of these, 98 are duplicate papers that cite more than one BMML, resulting in a final set of 256 unique IS conference papers that cite one or more of the 17 BMMLs. Because the number of citations identified is manageable, we did not sample but analyzed all 256 citations.

Finally, to identify *relevant citations*, we required citations to deal with the BMMLs they cite in a non-trivial and non-marginal way, for example, by extending BMMLs (e.g., Joyce & Paquin, 2016) or evaluating their advantages compared to competing approaches (e.g., Eppler & Hoffmann, 2012). For identifying such citations, we read the title and abstract of each paper and examined the text passages that contain references to one of the previously identified BMMLs. This process led us to reject 863 citations (659 journal papers; 204 conference papers), leading to a final sample of relevant citations comprising 139 citations (87 journal papers; 52 conference papers), which we read in-depth. Figure 4 offers a representation of the various steps followed in Stage 2 and the respective results.

[5] We combined the "cited by" feature with the advanced search field "source" in Google Scholar. For each conference, we searched for both the acronym (e.g., ICIS) and the conference name (e.g., International Conference on Information Systems).

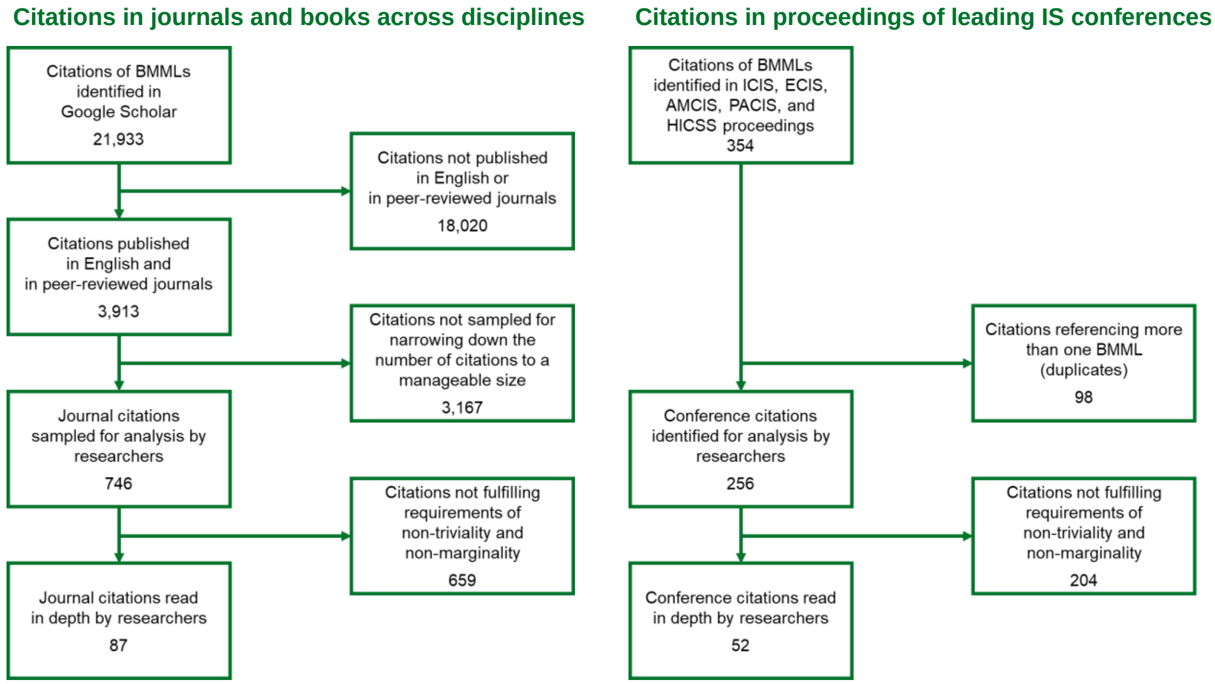

Figure 4. Multi-step process for identification of citations of Business Model Modeling Languages (BMMLs)

4 Business Model Modeling Languages

The 17 BMMLs have been developed by scholars in disciplines as varied as strategy, IS, computer science, accounting, and sustainability. In the following, we contrast, and compare these BMMLs along the previously discussed dimensions of modeling languages, namely, semantics, syntax, and pragmatics.

4.1 Semantics: The Meaning in Business Model Modeling Languages

The semantics in BMMLs refers to the “vocabulary” they use, i.e., the content or meaning that BMMLs intend to express using several semantic constructs (e.g., activities, resources, actors, exchanges). Each BMML comprises its unique set of semantic constructs. Oversimplifying somewhat, comparing BMMLs from a semantic point of view fundamentally means analyzing the extent to which they share a similar understanding of what a business model comprises (e.g., Moody, 2009).

Indeed, there are several possibilities to represent the content of a business model as a function of the semantic constructs used. BMMLs could, for example, adopt the semantic constructs *choices* (e.g., using local rather than overseas suppliers) and resulting *consequences* (e.g., higher sourcing cost and faster response times, e.g., the *Causal Loop Diagram* by Casadesus-Masanell & Ricart, 2010). Alternatively, BMMLs could seek to represent a business model through the semantic constructs *actors* and (their) *exchange relationships* (e.g., *e3value* by Gordijn & Akkermans, 2003). Insights from the domain of conceptual modeling suggest that no set of semantic constructs of a given BMML is universally better. Nonetheless, semantics matter because they crucially determine what the BMML can be used for (e.g., Moody, 2009). This is because if a BMML is lacking the desired semantic constructs, the user needs to either abstain from modeling the related semantics or extend the BMML itself. Abstaining from modeling those semantics, depending on the case, may not be an option. Extending a BMML itself might, in turn, add considerable complications (e.g., compromised clarity and/or understandability of the BMML, effort involved in adapting software-based tools that support using BMMLs, or in ensuring their user acceptance). This illustrates the importance of semantics in BMMLs for their use and further development.

To analyze and compare the semantics in different BMMLs we adopted the definition of the business model provided by Al-Debei and Avison (2010, based on Al-Debei & Fitzgerald, 2010) as our reference. Al-Debei and Avison (2010) define a business model as consisting of the following four dimensions:

(1) value-network, (2) value-finance, (3) value-proposition, and (4) value-architecture. These primary dimensions consist of a total of 16 sub-dimensions[6].

The dimension *Value-network* includes the *actors* of a business model and their *roles* (an actor can assume more than one role within a value network). It also includes *relationships*, which denote the level of intimacy between actors (e.g., no relationship at all, a simple sourcing relationship, or a strategic partnership). Furthermore, the value network comprises the objects that are exchanged (*flow-communication*), the *channels* used for these exchanges (physical or electronic), the *governance* (i.e., what kind of power actors have within the network) and *network-mode* (open or closed), which describe whether new ideas can be introduced to the network by any actor or only by selected actors. The dimension *Value-finance* contains the *revenue structure*, which describes how revenues are divided among actors, the *total-cost-of-ownership*, and the *pricing method*. The dimension *Value proposition* comprises the products or services offered (*product-service*), the targeted customers (*target-segment*), and the benefits that the product-service is intended to provide to customers (*intended-value-element*). The dimension *Value architecture* includes *core-resources*, which are combined through the *value-configuration* (i.e., business processes) to enable *core-competences*. The *value-configuration* thus describes how resources are turned into value creation activities by means of business processes and competencies required to run these processes.

We selected this definition following its coherence with several criteria that we considered central to the goals of this study. First, we considered it important for the reference definition to be consistent with the understanding of the business model prevalent in the disciplines that the reviewed languages originate in (so as not to bias the semantic analysis towards one or several of these disciplines). Second, the reference definition had to be comprehensive in its scope (so as not to bias the analysis of the semantics toward specific constituents of the business model construct). Third, we needed a definition that supports a sufficiently fine-grained vocabulary (to allow for a non-superficial comparison of the languages). Finally, it had to be comprehensive enough to cover general emerging themes that act as a common denominator across various definitions of the business model (Zott et al., 2011). Al-Debei and Avison (2010) offer a definition based on a systematic analysis of definitions selected from the fields of business management, eCommerce, eBusiness, and IS. The systematic analysis is conducted through a semantic analysis, thus offering a more robust approach (in the sense of it being objective, transparent, and replicable) than analyses that are conducted in an *ad hoc* fashion (Rich, 1992). This approach is also coherent with the business model being a system-level construct, centered on activities, emphasizing value creation and value capture, which refers to what Zott and colleagues have denoted as "emerging themes" across different fields of business model research (Zott et al., 2011).

To analyze and compare the semantics in our identified languages, two of the authors of this paper independently mapped each semantic construct of all BMMLs to the dimensions and sub-dimensions identified by Al-Debei and Avison (2010); inconsistencies were resolved through subsequent discussion (see Appendix E for the resulting mapping).

Despite some overlap, the overall picture is quite heterogeneous, and five main points can be observed. First, the BMMLs differ greatly regarding the semantic constructs they employ. For example, while the *Business Model Canvas* and the *Value Delivery Modeling Language* (OMG, 2015; Roelens & Poels, 2015) cover most of the (sub-)dimensions defined by Al-Debei and Avison (2010), the *Eriksson-Penker Business Extensions* (Eriksson & Penker, 2000) address only two, namely, resources and core-processes. Second, the terminology of the semantic constructs is not consistent, as in many cases different terms are used for the same semantic constructs (e.g., actor/agent/member/participant all denote semantic constructs with strongly overlapping meaning). Third, certain areas of agreement emerge. For example, all but two approaches (i.e., *Diagrammatic Business Model Representation* (Boritz, Carnaghan, & Alencar, 2014) and *Eriksson-Penker Business Extensions*) employ the semantic construct *actor*. Fourth, the semantic constructs differ in terms of their level of abstraction (Massa & Tucci, 2014); with some languages using aggregate semantic constructs and others more detailed constructs (e.g., an aggregate construct *actor* vs. more detailed semantic constructs that distinguish between actors that are *suppliers* and *allies*). Fifth, several approaches define semantic constructs that fall outside the semantic structure of a business model as defined by Al-Debei and Avison (2010). For example, the *Strategic Business Model Ontology*

[6] Al-Debei and Avison (2010) refer to these *sub-dimensions* as *constituent elements*. We purposefully adopt the term sub-dimensions for clarity reasons, to avoid confusion with other uses of the term element we make in this article.

(Samavi et al., 2009), the *Diagrammatic Business Model Representation*, and the *Eriksson-Penker Business Extensions* each provide constructs for representing strategic goals.

Besides the similarities and differences highlighted above, BMMLs can also be classified on a more general level according to their (semantic) scope and granularity (see Figure 5). To identify a BMML's (semantic) scope and granularity we relied on the structure we introduced at the beginning of this section, which comprises four dimensions (e.g., value-network, value-financing, value-position, and value-architecture) as well as 16 sub-dimensions (Al-Debei and Avison, 2010; Al-Debei and Fitzgerald, 2010; for more details see Appendix C). The scope of a BMML is defined by the number of semantic sub-dimensions that a BMML covers in this structure (e.g., the semantic sub-dimension *Intended-value-element*). The granularity of a BMML is defined by the number of unique semantic constructs that a BMML distinguishes (e.g., the semantic construct *Value proposition*). Contrasting and comparing BMMLs in terms of scope and granularity leads to the identification of the following four groups of BMMLs:

1. **BMMLs with lower scope and lower granularity:** This group includes 10 BMMLs that cover eight or fewer semantic sub-dimensions. Most of the 17 BMMLs are found in this group.
2. **BMMLs with moderate scope and higher granularity:** This group comprises two BMMLs characterized by exceptional granularity (*Value Delivery Modeling Language* and *Framework for New Business Models*). The granularity of both BMMLs is at least twice that of other BMML groups.
3. **BMMLs with higher scope and lower granularity:** This group comprises two BMMLs that are characterized by exceptional scope (*Causal Map* and *Causal Loop Diagram*). These are the only two BMMLs that map all 16 semantic sub-dimensions, which is mainly because their semantic constructs are abstract (e.g., concepts and links).
4. **BMMLs with moderate scope and granularity:** This group comprises exactly one BMML, the *Business Model Canvas*. With its nine semantic constructs, it covers 11 semantic sub-dimensions.

The heterogeneity amongst both semantic constructs and granularity/ scope has implications for future research, as will be discussed later.

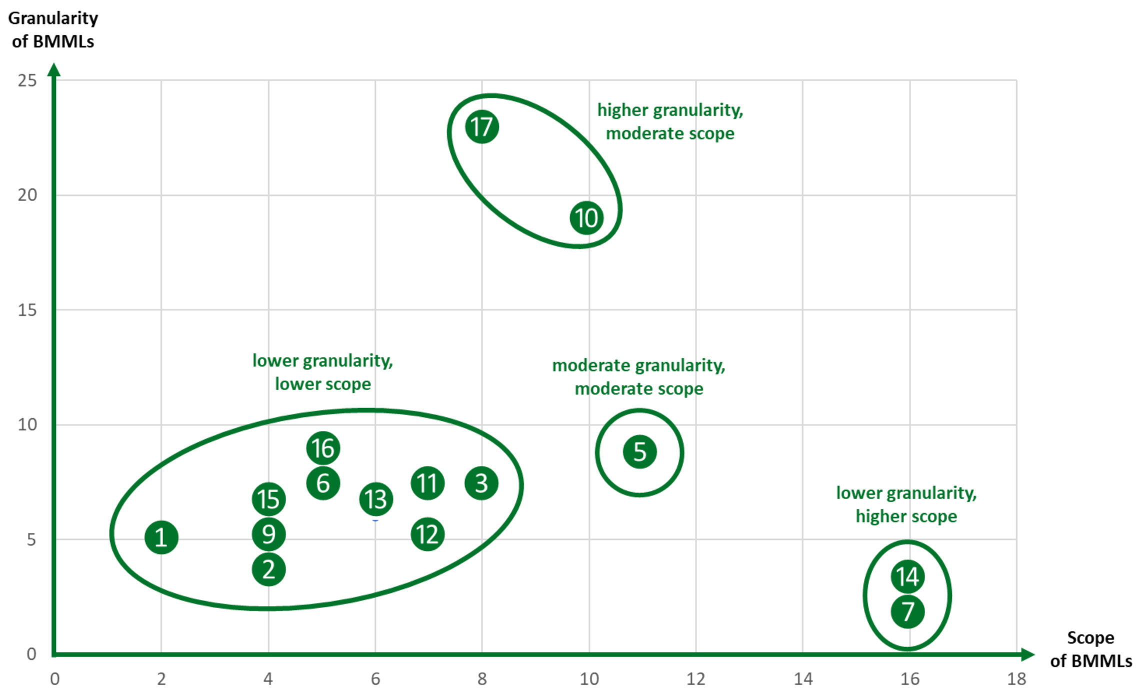

Figure 5. Granularity and scope of Business Model Modeling Languages (BMMLs)[7]

[7] Note to Figure 5: ❶ Diagrammatic Business Model Representation (Boritz et al., 2014), ❷ Resource-Event-Agent (Sonnenberg et al., 2011), ❸ e3value (Gordijn & Akkermans, 2003), ❹ Eriksson-Penker Business Extensions (Eriksson & Penker, 2000), ❺ Business Model Canvas (Osterwalder & Pigneur, 2010), ❻ Business Models for eGovernment (Peinel et al., 2010), ❼ Causal Map

4.2 Syntax: The Visual Form and Visual Notation of Business Model Modeling Languages

While the semantics of a language refers to *what* a language represents, the syntax determine *how* a language represents that meaning visually (Moody, 2009). As introduced earlier the syntax comprises both visual form and visual notation. In contrasting and comparing our reviewed original BMMLs, we focus mainly on the visual form. We do this for two reasons. First, to the best of our knowledge, we lack robust criteria for comparing the visual notation of different BMMLs (e.g., Moody, 2009). Second, prior research has offered insights into how to compare BMMLs in terms of their visual forms (e.g., Botturi, Derntl, Boot, & Figl, 2006; Costagliola, Delucia, Orefice, & Polese, 2002).

Prior research has suggested that the following characteristics can distinguish the visual form of a BMML: (1) the employed visual form of a language (Costagliola et al., 2002), (2) the number of views a language uses; and (3) the relationship between these views (Botturi et al., 2006).

A *view* is "an abstraction from a specific viewpoint, omitting details that are irrelevant to that viewpoint" (Eriksson & Penker, 2000, p. 4). For example, when representing a human body, a view could involve only showing the skeleton, or the nervous system, and omitting everything else. Both views would address the same object (the human body) but focus on different constituents of the human body and serve different purposes. They could, however, also be combined into one view that represents the skeleton as well as the nervous system. This reasoning also applies to modeling languages, making the number of views an important characteristic of a language (Botturi et al., 2006). Moreover, the question arises as to what the relationship is between these views, namely whether they are *overlapping* or *non-overlapping* (Botturi et al., 2006). To return to our example, assuming that there is no direct connection between the nervous system and the skeleton, the views for each would provide complementarily, but non-overlapping views of the human body. In contrast, if there were two views of the skeleton, one for the upper half and one for the lower half, then the hip might be included in both views, hence making these views overlapping. Accordingly, the relationship between views also forms an important characteristic of a modeling language (Botturi et al., 2006). One or more views as well as combinations of views can be used in different contexts. It is both possible that all views of a BMML can be used by all stakeholder groups and for all task types, but also that a view of a BMML can only be used by one stakeholder group for a specific task type. Concerning the business model, we found evidence of the presence of different views in languages (see Table 1). According to the previously mentioned characteristics of visual forms, our review reveals the following:

1. **Visualization approach:** According to the visual form, BMMLs can be categorized into two categories: map-based (or geometric-based) and network-based (or connection-based) approaches (Costagliola et al., 2002). While both define a set of concepts to represent a business model, the way they visualize these concepts, however, differs greatly. Map-based approaches lay out the concepts one by one, thereby providing a template for spatially structuring a specific business model's key characteristics. For each concept (e.g., actor, activity), the semantic constructs belonging to the concept (e.g., customers and suppliers) are listed in their respective spatial position. Network-based approaches rely on a different visualization approach. They explicitly visualize every single semantic construct of a given concept (e.g., every customer segment and supplier are visualized separately) and the relations among these semantic constructs, i.e., they use a network of semantic constructs to represent a business model (Costagliola et al., 2002). The vast majority of languages (i.e., 13 out of 17) use a purely network-based visual notation, which means that they allow describing a business model through networks consisting of concepts (e.g., actors) and connections between them (e.g., relationships between actors). Three languages, including the *Business Model Canvas*, are relying on a purely map-based visual form. Only one language, namely

(Cossette, 2002; Tsai et al., 2011), ❽ eBusiness Model Schematics (Weill & Vitale, 2001), ❾ Strategic Business Model Ontology (Samavi et al., 2009), ❿ Value Delivery Modeling Language (OMG, 2015; Roelens & Poels, 2015), ⓫ Value Stream Map (Pynnönen et al., 2008), ⓬ Service Dominant Business Model Radar (Turetken et al., 2019), ⓭ Activity System Business Model (Gaspareto & Henriqson, 2020), ⓮ Causal Loop Diagram (Casadesus-Masanell & Ricart, 2010), ⓯ Value Map (Allee, 2000; Tapscott et al., 2000), ⓰ Value Net (Parolini, 1999), ⓱ Framework for New Business Models (Vorraber & Müller, 2019). For more details on the scope and granularity of each BMML see Appendix C.

Diagrammatic Business Model Representation, uses a hybrid approach that combines a network- and a map-based notation. BMMLs spatially structure semantic constructs (such as the resources, processes, etc. that are relevant for a given business model) in boxes with a fixed title and position (a typical characteristic of map-based notations). Also, BMMLs visually describe semantic constructs by having a visualization (such as circles for semantic constructs and arrows for relationships between semantic constructs) for every single semantic construct (a typical characteristic of network-based notations). Since the *Diagrammatic Business Model Representation* uses typical characteristics of both visualization approaches (map-based and network-based), it employs a hybrid visual notation.

Table 1. Syntax: The visual form of Business Model Modeling Languages

			Diagrammatic Business Model Representation (Boritz et al., 2014)	**Resource-Event-Agent** (Sonnenberg et al., 2011)	**e3value** (Gordijn & Akkermans, 2003)	**Eriksson-Penker Business Extensions** (Eriksson & Penker, 2000)	**Business Model Canvas** (Osterwalder & Pigneur, 2010)	**Business Models for eGovernment** (Peinel et al., 2010)	**Causal Map** (Cossette, 2002; Tsai et al., 2011)	**eBusiness Model Schematics** (Weill & Vitale, 2001)	**Strategic Business Model Ontology** (Samavi et al., 2009)	**Value Delivery Modeling Language** (OMG, 2015; Roelens & Poels, 2015)	**Value Stream Map** (Pynnönen et al., 2008)	**Service Dominant Business Model Radar** (Turetken et al., 2019)	**Activity System Business Model** (Gaspareto & Henriqson, 2020)	**Causal Loop Diagram** (Casadesus-Masanell & Ricart, 2010)	**Value Map** (Allee, 2000; Tapscott et al., 2000)	**Value Net** (Parolini, 1999)	**Framework for New Business Models** (Vorraber & Müller, 2019)
Visual form	Visualization approach	Network-based		X	X	X		X	X	X	X	X	X			X	X	X	X
		Map-based					X							X	X				
		Hybrid	X																
	Number of views	One	X		X		X	X	X	X			X	X	X	X	X	X	
		Several		2		4					2	4							4

2. **Number of views:** A majority (12 of the 17 BMMLs identified) have only one view, whereas five have more than one view. The thematic focus of the views, however, greatly differs: Both within a language between views and between languages (including those with only one view). Examples include views of the structure of the value network that an organization's business model is embedded in (e.g., actors and their relationships, Gordijn & Akkermans, 2003), of the causal relationships between business model elements (e.g., a low-price policy leads to the acquisition of price-sensitive consumers, Casadesus-Masanell & Ricart, 2010), and of the relationship between strategic goals (e.g., being the market leader in terms of market share and offering a premium product might be conflicting goals, Samavi et al., 2009).
3. **Relationship between views:** The five languages that have multiple views each offer overlapping views for at least some constructs. Samavi et al. (2009) propose an operational and a strategic view. In the operational view, actors are represented with their tasks, relationships, and operational goals. Such operational goals would include, for example, that a certain service is provided to customers without interruption. In the strategic view, these operational goals are related to strategic ones such as increasing shareholder value. Sonnenberg et al. (2011) also distinguish between two views, but with a completely different focus: The duality model and the value chain model. The duality model describes value creation with stakeholders inside an organization (i.e., the transformation of resources) and outside of it (i.e., transfer of resources). The value chain model describes transformation and transfers (from the duality model) as part of business processes which in turn become part of

value chains. Eriksson and Penker (2000) suggest four views that describe an organization's goals (business vision view), value-creating interactions between activities and resources to reach these goals (business process view), organizational structures of the resources (business structural view), and interactions of resources in a business model (business behavioral view). The *Value Delivery Modeling Language* (OMG, 2015; Roelens & Poels, 2015) has five views relevant to the business model concept. These describe how value propositions are exchanged (value proposition exchange) and structured (value proposition structure), how stakeholders are organized (business network structure), how an organization employs capabilities (capability management), and how a business model makes use of business processes (activity diagrams). The *Service Analysis and Engineering Framework for New Business Models* (Vorraber & Müller, 2019) propose four different views of which one forms the basis to represent business models (value exchange and resources) and the other three allow one to detail business models concerning dynamics and motivation, legal aspects, as well as values and needs. The degree of abstraction for each view is very different and individual to each BMML.

4.3 Pragmatics: The Use Context of Business Model Modeling Languages

Pragmatics mainly refers to the characteristics of the user and of the task to which the language is applied (Wand & Weber, 2002). User characteristics include their preferences, cognitive abilities, domain knowledge (e.g., knowledge of a specific business model), and prior experience with the language or with modeling languages in general. The task refers to the goal or purpose of why the language is used (e.g., to understand, communicate, or generate new ideas) as well as how the language is supposed to be used, such as the medium that a language is used with (e.g., a whiteboard, pen and paper, or software).

Concerning user characteristics, we found a major difference arising from the type of audience a BMML is primarily targeted at: depending on their prevailing perspective and background, a business audience is likely to take a more economic and analytical approach and use the BMML to, for example, improve the economic viability of a business model (Casadesus-Masanell & Ricart, 2010), compared to users with a more technical background and outlook, e.g., engineers (Gordijn & Akkermans, 2003). This difference notwithstanding, we observe little variance across the languages analyzed, as the authors of the respective BMMLs typically see their BMMLs as, for example, "lightweight approaches" (Gordijn & Akkermans, 2003, p. 116), which can "easily describe and manipulate business models" (Osterwalder & Pigneur, 2010, p. 15), implying they should be accessible to both expert and novice users.

Tasks tend to vary. An important attribute of BMML tasks arises from their domain of application. Our review reveals that while most of the BMMLs are intended to be applicable across domains (see *scope* in Table 2), there are also two domains that are addressed by BMMLs specifically, namely eGovernment services (Peinel, Jarke, & Rose, 2010) and eBusiness (Weill & Vitale, 2001; Gordijn & Akkermans, 2003). The domain-specific scope of BMMLs has no consequences for the variety of purposes for which such BMMLs are employed. The proposal of a BMML is sometimes accompanied by the provision of software. The core functionality of these software-based business model development tools is the representation of a specific BMML and functionalities that simplify the use of this BMML. Also, they provide functionalities such as for developing, evaluating, and revising business models through digital supports as well as for digitally tracking business model changes over time. In this way, such software-based business model development tools allow the documentation and sharing of decision-relevant information of business model innovation processes as well as enable users to work on business models collaboratively, including overcoming the users' spatial dispersion (Szopinski et al., 2020).

In addition, our review reveals that the intended purposes for using BMMLs vary substantially, depending on the discipline that a language has been proposed in (see *origin* in Table 2). This aspect, namely the existence of a relationship between the objectives of using BMMLs and the field of enquiry in which BMMLs are used, is also maintained in relation to the use of BMMLs (see section 5. Research based on Business Model Modeling Languages).

Overall, our review reveals that BMMLs are proposed to support five conceptually distinct, and yet often related, purposes (for details, see Appendix D, which reports, for all BMMLs, the sentences indicating how the authors intended the BMMLs to be used in the original work).

- **Understand a business model and communicate about it** (Eriksson & Penker, 2000; Gordijn & Akkermans, 2003; Osterwalder et al., 2005): BMMLs are seen to facilitate comprehension as well as to be less ambiguous than (informal) natural language, and thereby reduce the risk of misunderstandings.

- **Facilitate collective analysis and evaluation of a business model** (Gordijn & Akkermans, 2003): Individuals may not have the same understanding of concepts and semantic constructs (such as value proposition, or value creation and delivery) that are central to the analysis and description of a business model. For this reason, analysis of business models that rely only on natural language is prone to misinterpretation, disagreement, and, in general, problems in collective understanding, which can in turn create problems for the management of business models and business model innovation. This problem may be particularly salient in the context of IT-intensive value propositions, such as in ecommerce, since often these value propositions involve an entire range of stakeholders who need to coordinate action. BMMLs are seen to provide the foundation for a more structured analysis.
- **Deduce requirements for an organization's IS** (Eriksson & Penker, 2000; Gordijn & Akkermans, 2003): Businesses are increasingly reliant on sophisticated IS to run their business models. Google's business model, for instance, heavily relies on IT for (a) building and maintaining the search infrastructure (especially the search algorithm) and (b) managing the three main services (targeted ads, free search, monetizing content). The design and execution of business models that heavily rely on sophisticated IS necessitate understanding the requirements from all stakeholders of the business model. Research in IS has shown that it is easier to deduce requirements for stakeholders from a codified representation than from natural language descriptions (e.g., Wand & Weber, 2002). Building on such a premise, scholars in IS have proposed that BMMLs have the potential to support the development of IS that are better aligned with the corresponding business model (Gordijn & Akkermans, 2003). In the case of a business model being used as the starting point for the development of an IS, such as when users can gain access to a given service via a website and/or via a mobile app, using BMMLs can reduce the risk that different development teams interpret reality differently—and potentially develop incompatible systems (Eriksson & Penker, 2000).
- **Generate business model ideas** (Eriksson & Penker, 2000; Osterwalder & Pigneur, 2010): Creating explicit representations of a business model can facilitate experimenting with and generating new business model ideas (Chesbrough, 2010; John & Kundisch, 2015), which is an important antecedent for business model innovation (e.g., Massa & Tucci, 2014; Täuscher & Abdelkafi, 2017; Cosenz & Noto, 2018) that is nowadays often driven by digitalization (e.g., Hess, Matt, Benlian, & Wiesböck, 2016; Legner et al., 2017).
- **Support design of software-based business model development tools** (Osterwalder et al., 2005; Samavi et al., 2009): Some authors suggest that managers and entrepreneurs may benefit from working with software-based tools for business model design. Envisioned benefits include, for example, comparing several business models or even simulate them dynamically. These tools need rigorous representations of business models to be of practical support to managers. And business model scholars have proposed that visual representations of the business model based on BMMLs can support achieving such goals. Differently from the purpose of *deducing requirements for an organization's IS*, the purpose of *supporting design of software-based business model development tools* is not to support the development of software through business models, but to support the development of business models through software.

To summarize, the languages have been developed in a variety of domains and for a variety of purposes that are relevant for the development of business models, either in specific domains or in general. Proponents of the original BMMLs have explicitly referred to five main purposes of the BMMLs. For many BMMLs, software-based business model development tools are available. Our analysis of how the original BMMLs have been used and developed in subsequent research offers additional insights into the pragmatics of BMMLs (e.g., whether the original purpose has been extended or tested under different boundary conditions and across contexts).

Overall, our analysis based on comparing and contrasting the 17 identified BMMLs reveals the following insights. First, and perhaps not surprisingly, there does not seem to exist a well-accepted set of semantic constructs for BMMLs. Second, various visual notations have been proposed to represent the semantic constructs, which vary regarding the number of views they provide for representing the semantic constructs, the relationship between these views, and their approach to visualization within these views.

Third, BMMLs have been proposed for various uses that include very different tasks (e.g., making sense of an existing business model versus generating ideas for a new business model that does not yet exist).

Table 2. Pragmatics: The use context of Business Model Modeling Languages

			Diagrammatic Business Model Representation (Boritz et al., 2014)	**Resource-Event-Agent** (Sonnenberg et al., 2011)	**e3value** (Gordijn & Akkermans, 2003)	**Eriksson-Penker Business Extensions** (Eriksson & Penker, 2000)	**Business Model Canvas** (Osterwalder & Pigneur, 2010)	**Business Models for eGovernment** (Peinel et al., 2010)	**Causal Map** (Cossette, 2002; Tsai et al., 2011)	**eBusiness Model Schematics** (Weill & Vitale, 2001)	**Strategic Business Model Ontology** (Samavi et al., 2009)	**Value Delivery Modeling Language** (OMG, 2015; Roelens & Poels, 2015)	**Value Stream Map** (Pynnönen et al., 2008)	**Service Dominant Business Model Radar** (Turetken et al., 2019)	**Activity System Business Model** (Gaspareto & Henriqson, 2020)	**Causal Loop Diagram** (Casadesus-Masanell & Ricart, 2010)	**Value Map** (Allee, 2000; Tapscott et al., 2000)	**Value Net** (Parolini, 1999)	**Framework for New Business Models** (Vorraber & Müller, 2019)
Pragmatics	Origin	Accounting	X	X															
		Computer science			X	X													
		Information systems					X	X	X	X	X	X	X	X					
		Strategy													X	X	X	X	
		Sustainability																	X
	Scope	Domain-specific			X[8]			X		X				X					
		General	X	X		X	X		X		X	X	X		X	X	X	X	X
	Purpose	Understand a business model and communicate about it	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Facilitate collective analysis and evaluation of a business model	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		Deduce requirements for an organization's information systems			X	X	X			X	X	X							X
		Generate business model ideas			X	X	X	X			X			X					X
		Support design of software-based business model development tools		X			X	X			X	X							

[8] *e3value* by Gordijn and Akkermans (2003) has been used for modeling all kinds of business models in subsequent research. Strictly speaking, however, the original paper addresses only ecommerce ideas.

	Software-based business model development tool available?	X	X	X	X	X	X			X	X				X			

5 Research based on Business Model Modeling Languages

How has research on BMMLs unfolded? What have the BMMLs been used for in research? To answer these questions, we analyzed subsequent research that has built on the previously described 17 BMMLs. The goal of this exercise is to offer an overview of the nature of research that has been conducted on BMMLs, to assess the state of knowledge, identify the main insights and gaps, and outline the opportunities for future research.

Our review of this body of work reveals that scholars have undertaken studies that revolve around two main clusters, namely (1) research *with* BMMLs and (2) research *about* BMMLs. The first cluster comprises citations in which BMMLs do not form the central subject of enquiry but are used as part of research concerned with other research questions. The second cluster, conversely, comprises citations in which the BMMLs do form the central subject of enquiry, for example examining BMML extensions or applications to other domains.

As noted earlier, we identified 139 citations published in peer-reviewed journals or proceedings of leading IS conferences, spread across four different research streams, namely, strategic management, IS, sustainability, and a fourth one, not anchored to any established field, which we labeled business models.[9] Our careful reading of these citations across research streams reveals both common themes, i.e., themes that are recurrent across fields, as well as field-specific ones, i.e., themes and sub-lines of enquiry about BMMLs that are specific to a field.

In the following sections, we offer a synthesis of the main insights from these citations, distinguishing between research *with* (see section 5.1) and *about* (see section 5.2) BMMLs. Our focus is the type of research question (or research objectives) that scholars have sought to answer (accomplish) and the role of the modeling language of the business model in such endeavors.

5.1 Research *with* Business Model Modeling Languages

Out of the 139 identified studies, 103 fall into this category. For each study and each stream of research, Table F1 (see Appendix F) illustrates which language has been used, what the language has been used for (its objective), and how it was used. The use of the BMMLs in research *with* is heterogeneous and unevenly distributed. More than half of the studies we examined used one of the two BMMLs: *Business Model Canvas* (most used) and *e3value*. Across all BMMLs, we identify seven reasons for using the languages in research:

1. **Describe the business model of existing organizations:** This is a recurrent theme in studies that conceive and analyze business models of real organizations, e.g., Internet-based real estate organizations (Cherif & Grant, 2014), entrepreneurial health ventures (Sundin, Callan, & Mehta, 2016), or manufacturing organizations (Witell & Löfgren, 2013). In this instance, a modeling language is used to map and synthesize information about a business model; and information collected from various sources such as, for example, websites, financial reports, press releases, or interviews (e.g., Pinto, Saur-Amaral, & Brito, 2017; Metallo, Agrifoglio, Schiavone, & Mueller, 2018; Heyes, Sharmina, Mendoza, Gallego-Schmid, & Azapagic, 2018). In addition to manually describing an organization's business models with a BMML, there are also attempts to automate the description by systematically searching an organization's ERP systems (e.g., Augenstein, Fleig, & Dellermann, 2018).

[9] 8 Our review reveals numerous papers whose central subject of investigation is the business model(s) itself (themselves). These studies are typically not anchored to any particular existing field (in our case, strategy, sustainability, or IS) as manifested, for example, by the lack of roots in any established theoretical foundation or stream of literature. We grouped these studies under a category named "business models" to highlight the focus on the business model as the object of enquiry in and of itself, detached from established theoretical traditions. We include in this category, amongst others, papers published in the emerging *Journal of Business Models*, or in journals focusing on phenomena such as electronic commerce, healthcare management, or energy (as opposed to sub-fields of management science).

2. **Understand network-based business models:** Several scholars have focused on trying to understand business models whose value creation function results from the (non-obvious) exchanges amongst a large number of players in a network of exchange partners (e.g., Mikkonen, Hallikas, & Pynnönen, 2008; Partanen & Möller, 2012; Rydehell, 2020). Besides the number of players in network-based business models, this applies particularly to business models where both market forces and technology drive the level and speed of transactions such as in Bitcoin ecosystems (Derks, Gordijn, & Siegmann, 2018). Hence, BMMLs are used to represent the actors, roles, and exchanges, and their dynamic interaction occurring at the level of a network. Not surprisingly, scholars have mostly used network-based modeling languages. An exception is research that uses the map-based *Service Dominant Business Model Radar*, which is specifically designed to visualize business models of services with many stakeholders (e.g., Gilsing, Türetken, Adali, & Grefen, 2018; Gilsing, Türetken, Özkan, B., Adali, & Grefen, 2020).
3. **Study business model innovation:** In these studies, scholars have adopted BMMLs to advance our understanding of business model innovation. Business model innovation entails both the design of novel business models (e.g., Peters, Blohm, & Leimeister, 2015; Grustam, Vrijhoef, Koymans, Poulikidis, & Severens, 2018; Polydoropoulou et al., 2020) when none is in place and the reconfiguration of existing business models (e.g., Rask, 2014; França, Broman, Robèrt, Basile, & Trygg, 2017; Lopez, Bastein, & Tukker, 2019). It spans different phases, such as opportunity recognition, ideation, implementation, and validation (e.g., McGrath, 2010; Todeschini, Cortimiglia, Callegaro-de-Menezes, & Ghezzi, 2017; Grimes, 2018). Scholars have also explored the potential of crowdworkers for the innovation of business models, for example, in the evaluation of business model ideas (e.g., Görzen & Kundisch, 2016; Görzen, 2019). Another typical research objective of studies using a BMML is to explore the similarities and differences between traditional/non-digital and modern/digital business models (e.g., Toutaoui & Benlian, 2020) and underlying organizational factors (e.g., Hoßbach, 2015). Increasingly, this also includes research aimed at supporting the innovation of business models through software (e.g., John, 2016; Augenstein & Mädche, 2017; Szopinski et al., 2020; Schaffer, Weking, & Stähler, 2020).
4. **Align business and IT in organizations:** Software lies at the core of many organizations' business models. Obviously, to support the functioning of a business model, software must be aligned with it. The integration of business model considerations in software development has the potential to support the alignment of business and IT (e.g., Tongrungrojana & Lowe, 2004; Bleistein, Cox, Verner, & Phalp, 2006; Musulin & Strahonja, 2018).
5. **Incorporate business models into software development methods:** Scholars integrating business models into software development methods focus on the generation of software coding (i.e., programming the software) in the tradition of so-called model-driven software development (e.g., de Castro, Marcos, & Vara, 2011; Sedbrook, 2012). Model-driven software development methods seek to automatically generate executable software from models that are created with modeling languages (here: with the help of BMMLs).
6. **Support business model implementation:** Several scholars have researched with BMMLs concerning the implementation of business models, a critical activity in business model innovation. Studies on the implementation of business models seek to ensure a fit between an organization's business model and strategy (Lin, Zhang, & Andersson, 2010), provide instruments for benchmarking and evaluation of business models (Shinde, Hirayama, Mugita, & Itoh, 2013), and support the implementation of business models with specific value propositions such as big data analytics (Segarra et al., 2016) or blockchain technologies (Morkunas, Paschen, & Boon, 2019). While business model innovation cannot be fully planned (McGrath, 2010; Massa & Tucci, 2021), more incremental, agile changes of an existing business model can benefit from a more standard planning activity aimed at understanding which parts of the business model to change, and when (Tura, Hannola, & Pynnönen, 2017).
7. **Support pedagogical goals in entrepreneurship:** Traditional entrepreneurship courses teach methods based on financial forecasting which, given the uncertainty related to new ventures, may be inappropriate (Jackson, Scott, & Schwagler, 2015). Departing from this premise, scholars have started to investigate the potential of moving from a financial model of a business to a conceptual model (Teece, 2010), and used BMMLs as a way to support this

goal and improve pedagogy in entrepreneurship, including technology entrepreneurship (e.g., Snihur & Tarzijan, 2018).

Summarizing the purposes of employing BMMLs for research, there is no systematic coherence between BMMLs and the purpose for which they are used. Very different BMMLs are used, partly also within the same research field, but for different purposes. Nevertheless, we identified, across purposes and research fields, four different ways of how the purposes described before are realized with the help of a BMML:

1. **Artifact development:** This includes artifacts as diverse as frameworks for management control systems (Lin et al., 2010), telemedicine business models (Peters et al., 2015), multi-sided platform business model patterns (Yablonsky, 2016), air transport business models (Pereira & Caetano, 2015) or a performance indicator system for small water supply utilities in Japan (Shinde et al., 2013). Furthermore, there are studies developing artifacts such as procedure models. These studies aim at integrating BMMLs into procedure models and suggest when to use BMMLs within these procedures: for example, a scenario-based procedure for business model change in which BMMLs are used to document the current business model of an organization before changing it (Sakellaridis & Stiakakis, 2011) or an agile procedure in which BMMLs are used to identify business models to commercialize technologies (Tura et al., 2017).
2. **Data collection:** This way of using BMMLs usually aims to capture the business model of an existing organization and is often accompanied subsequently by either using the data collected to create new artifacts (see the previous paragraph *Artifact Development*) or to analyze business models (see the following paragraph *Business model analysis*). The studies in our sample that seek to collect data on business models mostly rely on the *Business Model Canvas*.
3. **Business model analysis:** For analyzing business models, most of the studies in our sample employ the *Business Model Canvas*. On the one hand, studies analyze and compare the business models of several organizations within an industry, such as video game providers (Waldner, Zsifkovits, & Heidenberger, 2013), renewable energy entrepreneurs (Gabriel & Kirkwood, 2016), or creative organizations such as architects or advertising agencies (Pfeifer, Stanić, & Oberman Peterka, 2018). Others, on the other hand, analyze the business model of a single organization with a particular focus, such as price policy (Petri, 2014), big data (Segarra et al., 2016), or industry 4.0 (Müller, 2019). Among these studies, some studies focus on a single organization, which in turn has multiple business models (Snihur & Tarzijan, 2018). Furthermore, some studies analyze the role of business models across industries and between organizations. For example, by analyzing how value is exchanged in this context (Hacklin, Björkdahl, & Wallin, 2018), consultancies act as intermediaries (Pinto et al., 2017), and stakeholders interact (Rydehell, 2020) while innovating business models.
4. **Results communication:** Here, BMMLs are primarily used to communicate the results of a study in the form of business model prototypes. Scholars suggest, for example, different business models for the publishing industry (Standing, Tian, Martin, & Deng, 2008), for mobile phone providers (Lin et al., 2010), or photovoltaic facilities (Lam & Yu, 2016). More recently, scholars often propose business model prototypes for new technologies (e.g., Metallo et al., 2018; Polydoropoulou et al., 2020; Derks et al., 2018) or sustainability (e.g., França et al., 2017; Heyes et al., 2018; Lopez et al., 2019) in these studies.

5.2 Research *about* Business Model Modeling Languages

We identified 36 studies that do research *about* BMMLs across the four research streams, as revealed in the previous section (i.e., strategic management, IS, sustainability, and business models). Table G1 (see Appendix G) summarizes for each study, which BMML(s) is (are) being researched and what the BMML(s) is (are) researched for, as well as how this is done.

Our review reveals that only six of the 17 languages, namely *e3value*, the *Business Model Canvas*, the *eBusiness Model Schematics*, the *Causal Loop Diagram*, the *Value Map*, and the *Value Net*, have been the object of subsequent development. The *Business Model Canvas* is by far the most widely researched BMML (28 out of 36 studies in the sample). Overall, our review reveals the following eight purposes.

1. **Support the application of a BMML:** Generally, researchers rely on both empirical (e.g., Zolnowski et al., 2014) and theoretical approaches (e.g., John & Kundisch, 2015) to study the

application of BMMLs. More specifically, Allee (2008) offers guidelines on how to conduct a value network analysis using the *Value Map*. The guidelines are an extension of the pragmatics of a BMML as they provide support on how the *Value Map* is supposed to be used. In addition, Schwarz and Legner (2020) identify five typical communities of practice (i.e., business model innovation experts, business owners, decision boards, other internal stakeholders, and external stakeholders) and empirically examine the use of, amongst others, BMMLs.

2. **Support the development of software:** A recurrent theme in research about BMMLs is the integration of the comparatively new business model concept with modeling languages which were mostly developed before the business model concept emerged in research. This effort has revolved around two areas of investigation: the development of enterprise architectures (which are models that comprehensively describe an organization's structure at and across different levels, i.e., from a business as well as from an IT perspective) and the development of running software, which is often supported by modeling languages for specific purposes in the software development process. As a result, scholars link BMMLs to other types of modeling languages. For example, the BMML *e3value* is linked to

- modeling languages for systematically determining requirements at an early stage in software development (Gordijn, Yu, & van der Raadt, 2006);
- a Feature-Solution graph for systematically aligning features (i.e., requirements from stakeholders) to solutions, for example, in terms of the economic viability of an organization's business model (Baida, Bruin, & Gordijn, 2003); and
- modeling languages that allow software engineers to formally define conditions that must hold for a business model to be valid and thereby manages uncertainty when designing a business model and predicting its profitability (Johnson et al., 2014).

Furthermore, the sample includes a study that links the *Business Model Canvas* with *Archimate*, a modeling language for enterprise architectures to help business and IT stakeholders in an organization analyzing changes and deriving business as well as technical implications (Iacob et al., 2012).

3. **Design business model development software:** Johnson et al. (2014) provide a software-based business model development tool that allows making use of two linked visual (modeling) languages. The software has a graphical user interface to simulate business model scenarios and allows carrying out calculations for predicting a business model's profitability. Fritscher and Pigneur (2014) propose and implement features in business model development software such as colors for grouping, custom attributes, and positioning of elements, including a heat map that reveals where users of this software rarely or frequently look. The software uses the Business Model Canvas and thus also allows conclusions to be drawn about the BMML.
4. **Design business models for sustainability:** Scholars in the field of sustainability have built extensions to BMMLs to allow capturing aspects that are of interest when analyzing an organization from the viewpoint of sustainability. Oversimplifying somewhat, this mostly relates to the need for extending the traditional understanding of value creation to include the creation of social and environmental value. Research at the nexus between business models and sustainability extends BMMLs in two different ways: First, by adding new components and, second, by introducing new layers to an original BMML. For example, the *Circular Business Model Canvas* (Lewandowski, 2016) substantiates an extension of the *Business Model Canvas* through additional components that help to develop sustainable business models, for example, by reflecting the regeneration and reuse of resources (Lewandowski, 2016). Another example is a BMML that is specifically adjusted for visualizing the business models of co-operative and mutual organizations, which entails additional components such as purpose, member value proposition, governance, and share structure (Mazzarol, Clark, Reboud, & Mamouni Limnios, 2018). The extension of BMMLs with entirely new layers goes beyond the addition of components. For example, the *Triple Layered Business Model Canvas* (Joyce & Paquin, 2016) entails three different layers, each forming a particular perspective on economic (the original *Business Model Canvas*), environmental, or social value creation. Another example is the *Strongly Sustainable Business Model Canvas*, whose layers are designed to get users thinking about sustainability (Kurucz, Colbert, Lüdeke-Freund, Upward, & Willard, 2017). Some extensions especially aim to support experimentation of sustainable business models

(Baldassarre et al., 2020; Bocken, Schuit, & Kraaijenhagen, 2018). Most extensions in the field of sustainability add semantics and syntax to the original version of a BMML (e.g., Joyce & Paquin, 2016; Kurucz et al., 2017; Bocken et al., 2018).

5. **Investigate specific contexts:** Several approaches are employed to extend BMMLs to specific contexts: First, adding new components such as in the context of sharing economy (e.g., new components that reflect peer-to-peer sharing and collaborative consumption, Plenter, Fielt, Hoffen, Chasin, & Rosemann 2017) or risk analysis (e.g., new components that capture political or legal facets of a business model, Sousa, Manso, Costa, & Almeida, 2012 or Andreassen et al., 2018). Second, also in the context of business model risk analysis, color coding is used to indicate the robustness of a business model (Haaker et al., 2017). Third, adding new attributes of relations between components (e.g., for the risk analysis context, *Scale* is a metric for accounting information that indicates the success of a relationship, Sousa et al., 2012). Fourth, specifying existing components, i.e., describing components in a more fine-grained way by dividing a component into several, more distinct components. For example, to cope with the phenomenon of crowdsourcing (see Afuah & Tucci, 2012; Djelassi, & Decoopman, 2013), the component *Key Activity* of the *Business Model Canvas* may be divided into a part that concerns the organization (*Company Key Activities*) and another part that addresses the crowd (*Crowd Key Activities*) (Kohler, 2015). Likewise, to reflect the multi-sidedness of platforms, the component *Value Proposition* may be divided into a part that concerns the buyer (*Value Proposition to Customers*) and the supplier (*Value Proposition to Suppliers*) of platforms (Andreassen et al., 2018). Fifth, the extension of a BMML that consists of mainly new components and takes over hardly any or even no components from the original BMML. An example for such an extension of a BMML is the work of Kühne and Böhmann (2018; 2019), who propose an extension of the *Business Model Canvas* geared to data-driven business models. This approach is not so much aimed at replacing an existing BMML, but rather at using the original and the extended BMML (perhaps even in parallel). There are also examples of extensions that are not based on the *Business Model Canvas* but on *e3value*. John and Kundisch (2012) propose to incorporate real options into *e3value* to evaluate business models that contain options to change or extend the business model. Terrenghi, Schwarz, & Legner (2018) propose new design elements (e.g., arrows) to represent exchanged values in a more differentiated way, distinguishing different types of data, money, and benefits.

6. **Support pedagogical goals in entrepreneurship:** The *Business Model Map* (Leschke, 2013) is proposed to encourage students and investors, amongst others, to think in an entrepreneurial manner. For this purpose, the *Business Model Map* (Leschke, 2013) adds a substantial series of new components (e.g., *personal/entrepreneurial fit* and *exit alternatives*) to reflect personal as well as professional strengths and limitations of an entrepreneur or team of entrepreneurs (Leschke, 2013). This comprises extensions of both semantics and syntax of a BMML.

7. **Support business model idea generation:** Three studies in our sample explicitly investigate the task of business model idea generation. In the first study, Eppler and Hoffmann (2012) conduct a controlled experiment with 45 experienced managers that they randomly assigned into three groups for inventing a new business model. Each group is provided with the same task but with different tools in support of idea generation, namely the *Business Model Canvas* for one group, an empty PowerPoint-slide for the second group, and physical objects (such as children's toys, stationery, and office supplies) for the third group. Interestingly they found that using the *Business Model Canvas* facilitates the dynamics of groups (i.e., increases perceived collaboration), while it actually leads to less satisfaction with the results (i.e., it decreases perceived creativity and the willingness to adopt the business model idea). In the second study, Athanasopoulou and de Reuver (2020) carry out action research in which they analyze data from various sources (including interviews, emails, and workshops) to provide empirical evidence on how business model tooling facilitates business model idea generation; amongst others, this includes researching the BMML *Business Model Canvas*. They found three approaches to better facilitate the process of exploring, reframing, and comparing alternative business model ideas and, based on these, provide recommendations for further developing business model tooling. Both studies show empirically that BMMLs have the potential to significantly affect dynamics and creativity in groups working on the development of new business models and thus contribute to an understanding of a BMML's usage in general. In the

third study, John and Kundisch (2015) extend the Cognitive Fit Theory and illustrate that cognitive fit can promote problem solving performance for creative problems such as business model idea generation. They also use the *Business Model Canvas* for their research.

8. **Support the theoretical foundation of a BMML:** Some studies in our sample explicitly seek to ground BMMLs in theory. Following Gregor's (2006) types of theories, a design theory for a BMML may include justificatory knowledge on how to develop and use BMMLs, and thus is a theory for design and action (Gregor, 2006). An early study on this category suggests four general guidelines for the representation of business models. Becker et al. (2011) suggest distinguishing between a structural and a causal view and to integrate both views in representations for business models. A more recent study advances the theoretical understanding of, amongst others, a BMML through the lens of boundary objects (Schwarz & Legner, 2020). This study investigates distinct communities of practice and empirically examine their use to effectively manage knowledge boundaries in the context of business model innovation. Another study provides a design theory for visual inquiry tools (Avdiji et al., 2020; Avdiji et al., 2018). Based on three visualization projects, among which is a BMML (namely the *Business Model Canvas*), this study theorizes and formalizes knowledge by abstracting design features and design requirements. In addition, one study seeks to explain how business model visualizations (some of which are BMMLs) affect the cognitive effectiveness of such visualizations (Henike et al., 2020). By identifying five visual framing effects, Henike et al. (2020) aim to determine how these effects cognitively impact business model management and research. These studies support the theoretical foundation of BMMLs and give prescriptions in the form of design-relevant knowledge that informs the advancement of existing BMMLs or the development of entirely new BMMLs in the future.

Overall, research *about* BMMLs is conducted by scholars from different research fields for different reasons. Across the eight identified purposes there are three different ways of how these purposes are pursued to research *about* BMMLs.

First, studies that link BMMLs with other modeling languages. These studies are mainly rooted in the IS field in which modeling languages have a long tradition and which now integrate business models and their corresponding BMMLs with various models of software and software-based tools that implement these models. These studies suggest that organizations using software to support decision making and controlling can benefit from expanding the traditional focus on processes and transactions to one that also considers how processes and transactions are linked to an organization's value creation, delivery, and capture. The business model construct, and BMMLs, help IS scholars embrace this more holistic perspective and work to integrate it with more granular perspectives focusing on the architecture of an organization, its activities, processes, and transactions.

Second, studies that extend BMMLs with respect to the respective disciplinary background from which these studies emerge. These studies are not rooted in any particular research field. Rather, they take a multidisciplinary perspective, often manifested by the tendency to draw simultaneously from often distant theoretical perspectives, rather than anchored to the theoretical tradition of a consolidated field. Overall research in the respective disciplines highlights that using the business model concept in these fields (e.g., sustainability) requires explicitly modeling aspects variously related to an understanding of value creation which is broader than in traditional perspectives of the business model. The value created for customers and economic value created for the shareholders (value captured) remain important but are insufficient to represent value creation in terms of these fields. This applies mainly to extensions of the semantics and syntax of BMMLs, and occasionally to extensions of the usage of BMMLs. Even if scholars do not always justify the choice of a BMML that they expand, the Business Model Canvas seems to be suitable for this purpose as most extensions of the BMMLs have already been taken up by other scholars.

Third, studies that theoretically ground BMMLs (e.g., Schwarz & Legner, 2020; Avdiji et al., 2020). This kind of research forms a comparatively small part of the sample, although research *about* BMMLs could make a significant contribution to the field here. In practice, BMMLs are often chosen concerning a BMML's perceived practical applicability. In absence of well-founded knowledge about when BMMLs (i.e., in which phase of business model innovation), which BMMLs, and how BMMLs perform well, practitioners, as well as scholars, base their choice of BMMLs mainly on anecdotal evidence. This also applies to the (further) development, and probably more importantly, the evaluation of BMMLs. An example of an early evaluation of an adaptation and assessment of the *Business Model Canvas* is provided by Zolnowski and colleagues (Zolnowksi & Böhmermann 2014; Zolnowksi et al., 2014) with their formative evaluation, in which they collect empirical data, including about the application of the BMML by academics and industry experts. Both, evaluations of BMMLs for specific phases of business model innovation (e.g., Athanasopoulou & de Reuver, 2020; John & Kundisch, 2015) and for cognitive challenges in general (e.g., Henike et al., 2020; John & Kundisch, 2015) are valuable and desirable. With this citation analysis on research *about* BMMLs, we would like to provide orientation for research on this type of knowledge on BMMLs.

6 Moving Forward: Research Gaps, Research Challenges and Opportunities for Future Research

Throughout this review, we have sought to make sense of the rapidly evolving and growing BMML literature by identifying, contrasting, and comparing the different original languages that have been proposed and by inquiring into their use and impact on the research that has followed. In this section, we take advantage of the opportunity that this thorough analysis offers to suggest avenues for moving forward.

We proceed in two steps. We start by following suggestions of authors such as Schryen (2013) or Sandberg and Alvesson (2011) and describe important knowledge gaps that have emerged from our analysis. We also outline some of the challenges that we expect would be involved in filling these gaps. Our objective here is to offer a high-level analysis and description that would generate suggestions rather than prescriptions (see Gregor, 2006; Rowe, 2014). We use, as organizing criteria, the same dimensions used to compare BMMLs, namely semantics, syntax, and pragmatics.

Proceeding from the specific knowledge gaps and research challenges, we then view the literature at a higher level of abstraction and elaborate on what we consider broader opportunities for future research. We point the reader to existing lines of enquiry in areas such creativity or innovation management, which have the potential to contribute to research *with* and *about* BMML but that have not yet made inroad into the BMML literature. We also briefly elaborate on two emerging themes, namely digitally enabled business models and sustainability, which we deem important and also promising for research *with* and *about* BMMLs.

The aim is not necessarily to be comprehensive, but rather to offer to the reader a future-oriented elaboration based on our critical reading of the literature. Figure 6 offers an illustration and synthesis.

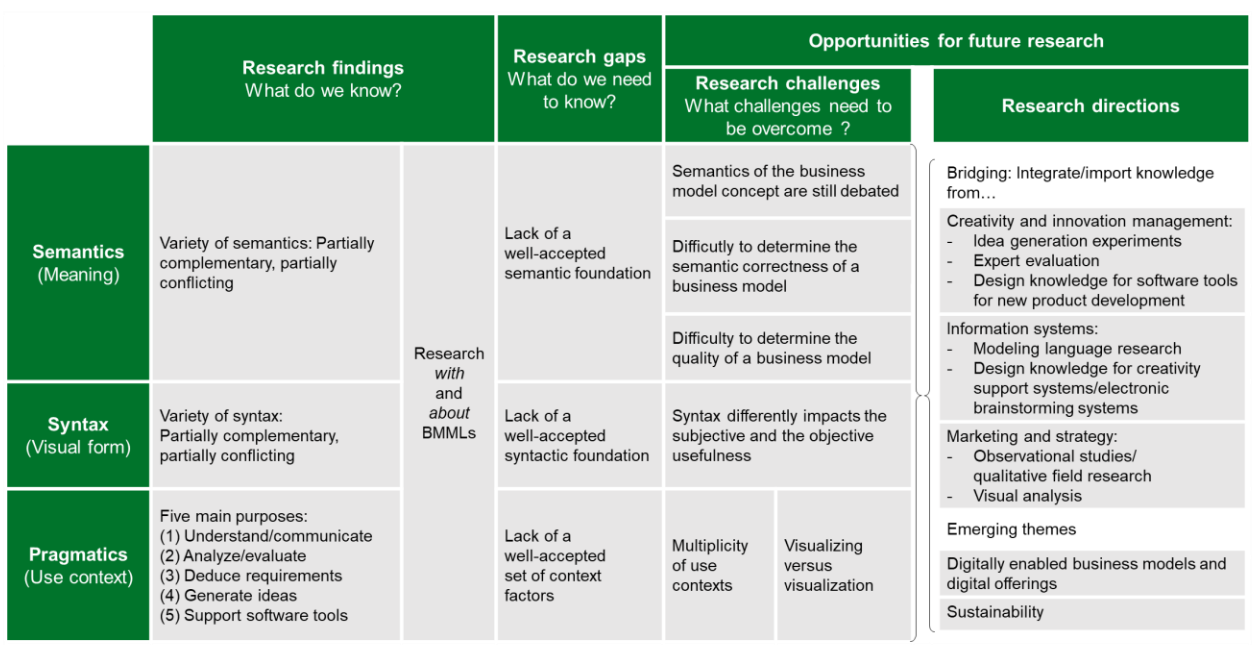

Figure 6. Three main perspectives for analyzing Business Model Modeling Languages (BMMLs) and the corresponding research findings, research gaps, and research directions

6.1 Research Gaps

6.1.1 Semantics: meaning

Lack of agreed-upon guidelines to justify the selection of semantics and use of terminology: As our review reveals, and despite some overlaps, there is disagreement concerning the semantics of BMMLs. Also, the use of terminology seems to follow a researcher's preferences or intuition rather than shared criteria for how to do it in a non-*ad hoc* way. A gap, in turn, is represented not so much by this lack of agreement but by the lack of shared, context-specific foundations that would guide the selection of semantic constructs. Overall, there is a need for guidelines to ensure a more coherent and transparent selection of semantic constructs and use of terminology to avoid, for example, confusion stemming from naming conceptually similar constructs differently, which creates construct validity problems. As this review reveals, this knowledge is currently lacking and perhaps, within some fields such as strategy, this gap has not even been recognized.

Lack of knowledge on the relationship between the semantics in BMMLs and their performance: Management research has found that the possibilities that visual tools (not only languages but also visual representations) offer for capturing information influence how managers divide their attention and how they make sense of their expertise: "Managers may *over-construct* their contributions to make them fit a particular visualization schema, i.e. they try to make sense of their past experience in an inaccurate way" (Eppler & Platts, 2009, p. 64). Hence, different BMMLs pointing to different semantic constructs make their users devote attention to different parts of a business model, which is likely to lead to different outcomes, such as, for example, business model ideas of different qualities (as using one set of constructs may lead to better business models than using another set of constructs). Research is needed to better understand the nature of the relationship between semantics and performance (e.g., Massa & Hacklin, 2020).

6.1.2 Syntax: visual form and visual notation

Lack of agreed-upon guidelines to justify the selection of syntax: Currently, available BMML research seems to be unable to provide arguments supporting the choice of syntax. This is a limitation because the syntax is likely to have a strong impact on the tasks for which BMMLs are used (see the following section). Many studies introduce specific visual notations and visual forms without providing theoretical arguments for their choices (for a notable exception, see Roelens & Poels, 2015). Research is needed to develop shared guidelines (as they exist already, for example, to apply process modeling languages, Mendling, Reijers, & van der Aalst, 2010) and theoretical arguments supporting the selection of syntax.

Lack of knowledge on the performance implication of choices concerning syntax: It is often put forward that a picture is worth a thousand words, and hence a graphical representation by its very nature is superior to a textual representation (Petre, 1995). However, prior research has found that visual representations are not always superior to textual representations. Rather, it is the "fit" between the characteristics of a task and the characteristics of a visual representation that determines whether a visual representation is indeed superior to other forms of representation (Vessey, 1991). Strategy research itself has questioned the unambiguous superiority of visualizations. For example, it has been claimed that visualizations can lead to superficial analysis and ambiguous communication (Eppler & Platts, 2009) and that visualizations can bias decisions through accentuating specific sets of options (Lurie & Mason, 2007). There are numerous types of such cognitive biases (e.g., overoptimism, overconfidence, illusion of control, and self-serving bias; Thomas, 2018). In this vein, modeling language research states that "apparently minor changes in visual appearance can have dramatic impacts on understanding and problem-solving performance" (Moody, 2009, p. 758). All this suggests that the notation and form of a visual representation (not only the modeling language) are highly important for its effectiveness and efficiency, but that the latter cannot be taken for granted. Research is needed to better understand the nature of the relationship between syntax and task performance.

6.1.3 Pragmatics: use context

Lack of a well-accepted set of context factors (what factors to consider when evaluating task performance?): More research is needed to clarify which real-life contexts BMMLs are used in or could be used in. The outlined purposes such as facilitated communication or analysis of a business model provide some indication of the relevant contexts. However, at a more detailed level, effectiveness and efficiency of BMMLs can depend on a variety of contextual factors such as the modeling medium (e.g., whether modeling is performed with software or a whiteboard, Moody, 2009), a user's level of modeling knowledge, or domain knowledge (Figl, 2017), and even the technologies behind the functioning of certain business models, such as cloud platforms or software-as-a-service (Benlian & Hess, 2011; Giessmann & Legner, 2016), amongst others. To move research forward, a comprehensive set of context factors needs to be identified (akin to the contribution made to process modeling research by Figl, 2017). What are the important contextual factors and what relationships do they hold (e.g., between mediators and moderators) with respect to different tasks?

6.2 Research Challenges

In this section, we describe some of the challenges presented by the above-mentioned research gaps. In line with prior contributions in the social sciences in general (Bhattacherjee, 2012) as well as in research on modeling language evaluation (e.g., Bera et al., 2014; Recker et al., 2011; Siau & Rossi, 2011), we took hypothesis testing (concerning the semantics as well as the syntax, and their pragmatics) in carefully designed experiments (or other forms of empirical validation) as a reference method to fill the main gaps (see Massa & Hacklin, 2020). As mentioned earlier the aim is to offer high-level suggestions and orientation rather than specific prescriptions.

6.2.1 Semantics: meaning

The semantics of the business model concept is still debated in research and practice: At an abstract level, there is an agreement that a business model describes how an organization creates, captures, and delivers value (e.g., Massa et al., 2017; Teece, 2010). At a more detailed level, however, there has been a long-lasting and still unresolved debate about the defining constituents of a business model. Absent an agreed-upon theory that would offer guidance and orientation, scholars are challenged by the need to justify their respective choice and use of semantic constructs for example by resorting to ad hoc conceptual theory development (i.e., theory development by conceptual reasoning), which may involve considerable research efforts. For empirical studies, this represents a considerable barrier. It would make conducting carefully designed empirical studies comparatively less attractive (given the needs to include extensive explanations to offer justification and gain legitimacy). In addition, there is no guarantee of comparability of empirical results, given the possibilities of employing a plurality of non-equivalent semantics across studies (see also next section). This problem is not likely to be resolved in the short-term and may create a barrier to cumulative progress on BMMLs.

It can be difficult to determine the semantic correctness of a business model created with a modeling language: Semantic correctness refers to the extent to which a semantic construct has been correctly used to capture what it is meant to capture (Ly, Rinderle, & Dadam, 2006). Compared to other types of modeling languages, the semantic constructs of BMMLs are rather fuzzy. In a process modeling language, for example, the semantics of constructs such as the *start of a process*, *end of a process*, or *task* can be defined rather precisely. Hence, for a specific process, it is comparably easy to decide whether the semantic constructs have been correctly used. Also, for process modeling languages metrics already exist, e.g., to evaluate the similarity of several process models (Dijkman, Dumas, van Dongen, Käärik, & Mendling, 2011). For example, a process that contains a task *kitchen* is not semantically correct because a kitchen obviously cannot be a task (while *clean the kitchen* could be). However, determining the semantic correctness of a specific business model (i.e., its semantic constructs) can be more complicated. For example, whether a certain resource (e.g., a patent, factory, or brand image) qualifies as a *key resource* of a business model can be subject to considerable debate, which is complicated by the fact that the answer is for the most part rather organization-specific and even observer-specific. This fuzziness is inevitable, at least to some degree, and perhaps even instrumental in allowing the users of BMMLs to be creative when generating business model ideas (Fritscher & Pigneur, 2009). However, it makes it more difficult to determine whether a certain representation of the business model is semantically correct (i.e., whether the semantic constructs of BMMLs have been used correctly). This difficulty also complicates the process of transferring evaluation approaches between or across modeling disciplines, with some disciplines relying on correctness measures (i.e., the errors made in representing a certain real-life instance through a modeling language) (Gemino & Wand, 2004). As mentioned earlier, this is an issue for empirical studies, given the importance of replication and, more in general, of comparability of results.

It can be difficult to determine the quality of a visual representation created with a modeling language: In most modeling domains, the goal of modeling (hence, the "quality") is to create models that faithfully represent the status quo of a subject matter (e.g., a process) or an agreed-upon future state of that subject matter (Wand & Weber, 2002). This implies that it is often not possible to determine the quality of the resulting models by checking whether the information captured in a model is a good fit with reality (or the requirements agreed upon concerning a future state of reality). Accordingly, modeling language research frequently uses experiments in which participants create a model from an existing textual description, and researchers later check whether the model complies with the semantics of that description. When using a BMML, however, especially when innovating a business model, the goal is to deliberately diverge from reality (i.e., diverge from all existing business models). Hence, to evaluate the usefulness of a BMML supporting business model innovation one has to determine the quality of (ideally) entirely novel business models. This makes evaluating the quality of a visual representation created with a BMML a daunting task.

6.2.2 Syntax: visual form and visual notation

Syntax may differently impact the subjective and the objective usefulness of a modeling language: In the context of visual programming, it has been reported that individuals sometimes perceive modeling languages to be superior to textual ones even when experimental evaluations do not indicate an advantage (Petre, 1995). Corresponding results are attributed to the *likability* of visualizations, and "sheer likeability should not be underestimated; it can be a compelling motivator" (Petre, 1995, p. 41). Similarly, in a survey of 1,500 users of one specific BMML, the *Business Model Canvas*, more than half of respondents affirmed that "[it] is a visual tool" (Strategyzer, 2015, p. 19), which was one reason for adopting this particular BMML. As a result, the subjective and the objective usefulness of BMMLs may not be always consistent, which might complicate the interpretation of experimental results. Also, a question remains as to whether it is possible to separate subjective from objective usefulness. Experimental research should find ways to deal with these confounding factors and disentangle their role to highlight the mechanisms involved in explaining the effectiveness and performance of different BMMLs. The works of Eppler and Hoffmann (2012), John and Kundisch (2015) and Henike et al. (2020), are notable examples of studies that investigate the cognitive impact of BMMLs.

6.2.3 Pragmatics: use context

Multiplicity of pragmatics: As in most types of modeling languages, we find a considerable diversity for BMMLs in terms of use. For example, BMMLs are not only employed for analysis and communication tasks, but also highly creative tasks. Moreover, this diversity is reflected in the users of BMMLs, such as experienced users working together with less experienced, or more casual users. Recognizing this diversity of uses in experimental designs increases the level of effort and sophistication involved in investigating BMMLs.

Visualizing versus visualization: Research in modeling languages tends to overlook the process by which individuals get to create shared understanding through engaging in the process of visualizing, which lies at the core of sense-making (e.g., Poels et al., 2006). And yet, in real organizational settings, the shared understanding and consensus that discussions about an organization's business model create among participants might be as valuable as the concrete results of these discussions. Therefore, it has been suggested to emphasize "visualizing over visualization" (Eppler & Platts, 2009, p. 70), because "the actual act of *visualizing*—the collaboration involved in rendering strategy content into graphic form, rather than the mere aesthetic of the outcome—is the vital sense-making activity" (Eppler & Platts, 2009, p. 67). Experimental approaches in modeling language research, however, often focus on the modeling outcome. A challenge thus is to shed light on how visualizing and visualization would distinctively impact different tasks.

6.3 Research Directions

In this section, we embrace a more systemic view and illustrate two possible high-level opportunities for research on BMML. The first one, consists in embracing an interdisciplinary approach that would allow bridging, integrating/importing specific existing knowledge. The second one, consists in moving research towards digital and sustainability which represents areas of ever-increasing importance which, we suggest, could represent fruitful lines of investigation for research *with* and *about* BMMLs.

6.3.1 Bridging, integrating/importing specific existing knowledge

In this section, we suggest that researchers on BMMLs can greatly benefit from the theoretical and methodological expertise accumulated in the following disciplines:

Creativity and innovation management: Researchers from these disciplines aim to understand how the creativity of individuals, groups, organizations, and even societies can be fostered (Amabile & Hennessey, 2010). As such, these disciplines are familiar with the challenge of determining the value of innovation ideas and with evaluating methods/tools for promoting idea generation. Especially the following two methodological contributions hold value for business model research: idea generation experiments and expert-based idea evaluation. In idea generation experiments, participants are given an idea generation task that participants in the treatment group solve with a specific idea generation method or tool, and participants in the control group without that method/tool (e.g., Dahl & Moreau, 2002; Goldenberg & Mazursky, 2002). Imaginative uses of BMMLs include specific cognitive stimuli used in conjunction with BMMLs to promote the ability to think outside the box and overcome occupational blindness, an important prerequisite for idea generation (e.g., Knoll & Horton, 2011). Experts then evaluate the quality (i.e., creativity/innovativeness) of the generated ideas. For this evaluation, considerable research has established the extent to which, and under what circumstances expert evaluations constitute valid measures for idea quality (e.g., Amabile, 1996; Baer & McKool, 2009; Magnusson, Wästlund, & Netz, 2016). In this experimental setup of idea generation and the subsequent expert evaluation, it is possible to evaluate idea generation techniques/tools and underlying theoretical propositions in a controlled manner. Adopting the methods of idea generation experiments and idea quality evaluation through experts may support research dealing with BMMLs.

Information systems: The IS literature, especially modeling language research, holds value for research in BMMLs. The relevant contributions include, for example, concepts and terminology for analyzing modeling languages (Burton-Jones et al., 2009; Moody, 2009), theoretically grounded guidelines for the design of visual notations (Moody, 2009; Avdiji et al., 2020), approaches for the semantic analysis of modeling languages (Wand & Weber, 2006), and comprehensive guidelines for the evaluation of modeling languages (e.g., Burton-Jones et al., 2009; Gemino & Wand, 2004; Siau & Rossi, 2011). In view of the experience of the IS discipline, imaginative uses of BMMLs and related future research could also aim to transform business models from one BMML to another (e.g., because they support different purposes) and to design standardized data formats for business models (e.g., for electronically storing and retrieving business models in databases).

Marketing and strategy: Some researchers in marketing and strategy research investigate how visual tools can support strategic decision making (Lurie & Mason, 2007) and strategy development (Eppler & Platts, 2009). These disciplines are therefore familiar with some of the challenges outlined above, especially those relating to the importance of the social context of using a visualization (pragmatics) and the fuzziness of the subject matter. In response to these challenges, marketing and strategy researchers have occasionally relied on workshop-based action research (Eppler & Platts, 2009) and observational field studies (Kaplan, 2011). Additionally, strategy researchers have proposed to employ visual analysis, which involves the analysis of "visual evidence of artifacts as they are used and as they change over time" (Jarzabkowski & Kaplan, 2015, p. 553), to understand the actual rather than the intended use of strategy tools. Summarizing, we suggest that empirical studies variously aimed at testing hypotheses of BMMLs would benefit from drawing on the methodological expertise from strategy and marketing research as outlined above.

Other possible useful streams and sub-streams involve research in cognitive sciences (as illustrated by Täuscher & Abdelkafi, 2017), particularly the line of enquiry that studies the relationship of visualization and the creativity of cognitive tasks (e.g., Zhang, 1997; Athanasopoulou & de Reuver, 2020). Another possibility is research on cognitive biases and decision making. Here an opportunity would stem, for example, in the integration of BMMLs into the development and implementation of debias training programs (e.g., see Sellier, Scopelliti, & Morewedge, 2019). In terms of theoretical foundations, useful insights may come from theories of human knowledge applied to conceptual modeling, such as work on ontology (particularly the work of Bunge, 1977, 1979), or speech act theory (Searle, 1977). Finally, a potentially fruitful line of enquiry comes from the application of a knowledge-based view of innovation in relation to business model innovation (e.g., Schwarz & Legner, 2020).

6.3.2 Emerging themes

In this section, we offer a high-level commentary on the opportunities stemming from research at the nexus between BMMLs and digital (notably digitally enabled business models) and BMMLs and sustainability.

Digitally enabled business models: Organizations in all industries are pursuing digitization strategies to transform business models that previously wrapped physical products/services into digital ones, sometimes with the goal of becoming a platform provider (e.g., Beverungen, Kundisch, & Wünderlich 2020). In a similar vein, advances in digital technologies are variously creating new opportunities for organizations to design new offerings that are transforming the nature of the relationship between organizations and customers and also pose various managerial challenges, for example on how to monetize these new digitalized offerings which often rely on the provision of data, information as well as experiences (Shapiro & Varian, 1998; Tidhar & Eisenhardt, 2020). Phenomena such as these may require BMML studies, for example, to distinguish between physical and digital elements of business models in order to transform them or to better understand how to manage capturing value from digitalized offerings. As an example, future research can support examining whether, how and under what conditions BMMLs could facilitate knowledge search and recombination in digital transformation strategies through knowledge layering, knowledge integration, and knowledge grafting (Lanzolla, Pesce, & Tucci, 2021). Overall, the progressive shift from an economy based on physical products and services towards one dominated by data, information, and digital experiences is impacting the way organizations do business, in turn opening important opportunities for future research *with* and *about* BMMLs.

Sustainability: A central concern in research in sustainability has been how organizations can successfully integrate social and environmental issues in their strategies and how they can create social and environmental value in addition to economic one (e.g., Schaltegger, Lüdeke-Freund, & Hansen, 2012). Research in sustainability has variously recognized that doing so is not easy, because markets create structural barriers of various types (e.g., Jackson, 2009). One way to overcome such barriers is to implement sustainable business models that would support the diffusion of sustainable offerings, namely offerings that include social and environmental value creation (for example, offering coupled with recycling schemes or that integrate more sustainable sourcing practices) (e.g., Schaltegger, Hansen, & Lüdeke-Freund, 2016). Interest for research at the intersection between this increasingly important line of enquiry and BMMLs comes from the recognition that sustainable business models differ from more “normal” business models in at least three fundamental ways (Lüdeke-Freund et al., 2016), namely: (1) they assume a view of business as an engine of societal progress, (2) they include a broader notion of value—from primarily economic to also social and environmental, and (3) they undertake and offer a multi-stakeholder, system-level perspective on value creation—which include contemplating economic, social, and environmental value creation for several stakeholders, including communities, employees, and even the environment. Thus, sustainable business models challenge some of the traditional understanding of the notions of value, value creation as well as of the main stakeholders to consider, opening up opportunities for new research *with* and *about* BMMLs. As previously described, studies have been offered that extends or build on the received BMMLs to address some of the requirements of dealing with business models in relationship to sustainability. These initial contributions are very valuable but represent just a starting point. Several opportunities exist in this area.

Overall, our study invites considering more convincingly to draw insights from literature streams not traditionally considered in business model research, such as those outlined above. It is reasonable to imagine a research program in which the questions asked are anchored in the conversations pertinent and relevant to each field (e.g., sustainability researchers are likely to be interested in questions that are not necessarily interesting to scholars in fields such as strategy or IS) and yet answers are created by drawing on a rigorous but multidisciplinary reservoir of knowledge, including research methods and theories from adjacent disciplines and streams.

7 Discussion and Conclusion

In this study, we have offered what constitutes to the best of our knowledge the first synthesis, organization, and critical assessment of research on BMMLs. We hope that the contributions of this study could offer a first step toward the maturation of this increasingly important field of research, and in the long term to be on an equal footing with subdisciplines of modeling language research, such as modeling languages for process modeling (e.g., Recker et al., 2014; Recker et al., 2011; Recker & Dreiling, 2011) or data modeling (e.g., Parsons & Wand, 2008; Allen et al., 2006; Hitchman, 2003).

BMMLs are, as the term suggests, languages, i.e., more or less flexible communication devices that are the product of the quest for the task of modeling and visually representing the business model concept (as opposed to, for example, *ad hoc* visual representations). This quest—from how to visually represent *one* business model to how to visually represent (m)any business model(s)—invites a meta-reflection on the nature, dimensions, uses, performance, and boundary conditions of visual representations of the business model. In this concluding section, we offer four high-level observations that are, in our view, worth emphasizing, given their semantics and significance for inspiring subsequent research in this important area of enquiry.

First, representing a business model involves making design choices (Simon, 1996). There are two main classes of design choices, namely the semantics and the syntax. Choices concerning the semantics but also the syntax is in a condition of mutual interdependence with the third important dimension of BMMLs, namely its pragmatics. The pragmatics includes the boundary conditions for the use of the BMMLs and the purpose of modeling or of the model task (its intended representation). Intuitively, the semantics in BMMLs determines the nature of the phenomenon that can be described for its use as well as the conditions for doing so. BMMLs that are too “restrictive” may not provide sufficient explanatory power for certain tasks, for certain users, or for a certain medium. Or they can work in a given domain of application but not in others. Overall, visually representing a business model involves making choices about semantics as well as syntax in relation to pragmatics. Our study indicates that, in many instances, this aspect of working with BMMLs is rarely acknowledged and possibly not even recognized. We believe that the development of a more systematic study of BMMLs and of visual representations of the business model concept in general fundamentally requires scholars to acknowledge their choices, and the rationale behind them, in a more deliberate and explicit manner. This may be particularly true within disciplines such as strategy or sustainability, which do not yet have a well-established tradition in conceptual modeling, as noted below. Scholars are invited to inquire into the reasons behind their choices and make both choices and the rationale behind them explicit in their papers.

Second, our review reveals that BMMLs have been the object of study in three established fields, namely strategy, IS, and, to a lesser extent, but increasingly, in sustainability. It also reveals that each field tends to be characterized by a somewhat idiosyncratic conversation that unfolds within the field itself, resulting in the creation of development silos that are characterized by very little cross-contamination (as noted by Zott et al. 2011 regarding business model research in general). This limitation is particularly evident if one considers the potential benefits that stem from the cross-contamination of insights across silos. For example, research in IS has a relatively well-developed tradition concerning modeling languages, which has developed out of efforts dealing with the problem of how to represent information and what information to represent. However, both strategy scholars and sustainability scholars seem to be largely ignoring these developments. Likewise, as revealed by our analysis of research *with* and *about* BMMLs, strategy, and sustainability scholars have used BMMLs in support of goals that are largely overlapping with those of IS scholars and, in so doing, have produced different insights. These insights have in many cases not diffused in IS research. The tendency to develop silos is, we contend, a major limitation, which could be partly overcome by the emergence of novel conversations, as highlighted below. Overall, our study could provide a starting point toward developing a common ground and conversation across different disciplines, offering an opportunity of more cumulative progress.

Third, our study reveals the gradual emergence of a new conversation that goes beyond the boundaries of traditional research fields as outlined above (i.e., IS, strategy or sustainability) and that we have referred to as business models. A number of papers exist that focus on BMMLs and do so in a way that is detached from a specific field, as manifested for example by the tendency to simultaneously draw from and ‘mix’ literature that would normally be considered distant. Whether this is symptomatic of the progressive emergence of an interdisciplinary line of enquiry focusing on the business model exclusively (as, for example, revealed by the emergence of the *Journal of Business Models*) remains largely unknown. At the same time, we suggest that such an emerging line of enquiry could represent a way of unlocking progress in business model research by legitimizing a research program able to promote conversations across more established and yet distant fields. This could represent an opportunity to avoid the silo phenomenon in business model research.

Fourth, our study reveals the existence of several possibilities of and approaches for representing business models. Given the richness and complexity of business models, it is unlikely that research will evolve into a “one-size-fits-all” approach. This has key implications for both research and practice. It invites the rejection of hopes for convergence on one solution, unless risking extreme reductionism or over-complication. At the same time, it invites us to consider the potential benefits of a contingent approach, in which both scholars and practitioners are invited to ask contingent questions, such as, “for what classes of problems and challenges is a given modeling language more likely to work?” and to be specific about the performance criteria that give semantics and substance to the term “to work.” The general *impression* (and it is only an impression) emerging from this study is that this line of reasoning, which would look at the same phenomenon from multiple angles and in a reflective way, has only tentatively been considered.

In conclusion, in a global survey of 2,000 executives, more than 60 percent admit that their “difficulty to define an effective business model […] is a challenge killing the ability to innovate” (GE, 2018, p. 91). Likewise, business model researchers have called for more research on “tools and methods” as a way of supporting organizations in their business model innovation efforts (Schneider and Spieth, 2013, p. 23). BMMLs represent one possible tool and, given the success of at least one of the exemplars—the *Business Model Canvas*—they seem to prove their potential (Veit et al., 2014). Beyond visually representing business models, BMMLs have many other potential uses and tasks to make sense of or innovate business models. Nonetheless, research is lagging behind practice. While practitioners all over the world are increasingly experimenting with ways of visually representing business models, rigorous research is hampered by the current fragmentation of knowledge in the area, as well as by the lack of guidelines, criteria, and foundations that would allow to better build on each other’s work and promote theoretical understanding and empirical validation.

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Appendix A: Sample business models created with four different Business Model Modeling Languages

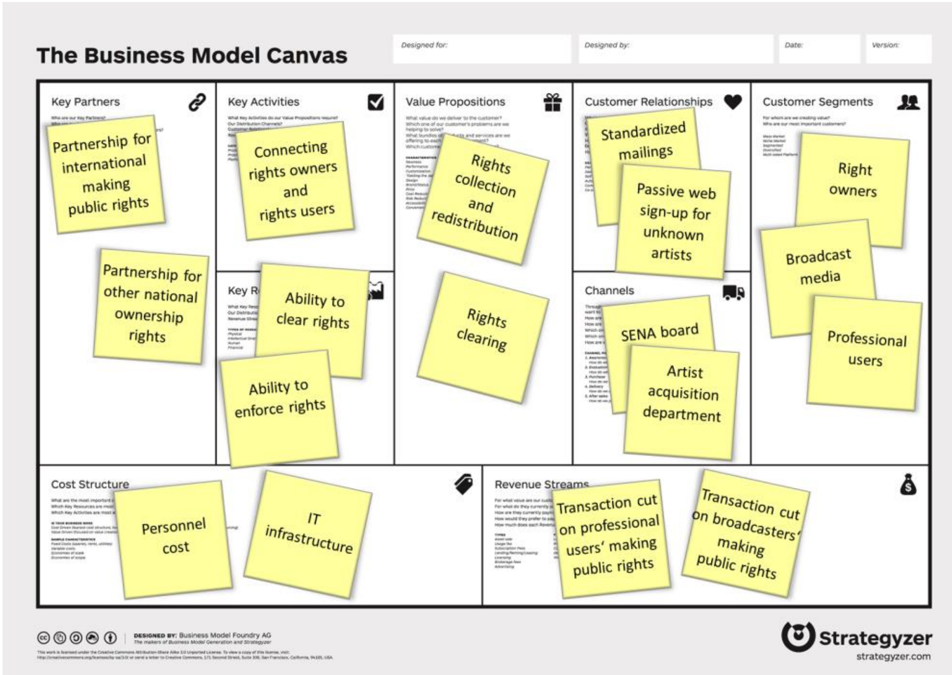

Figure A1. Business Model Canvas (Osterwalder & Pigneur, 2010)

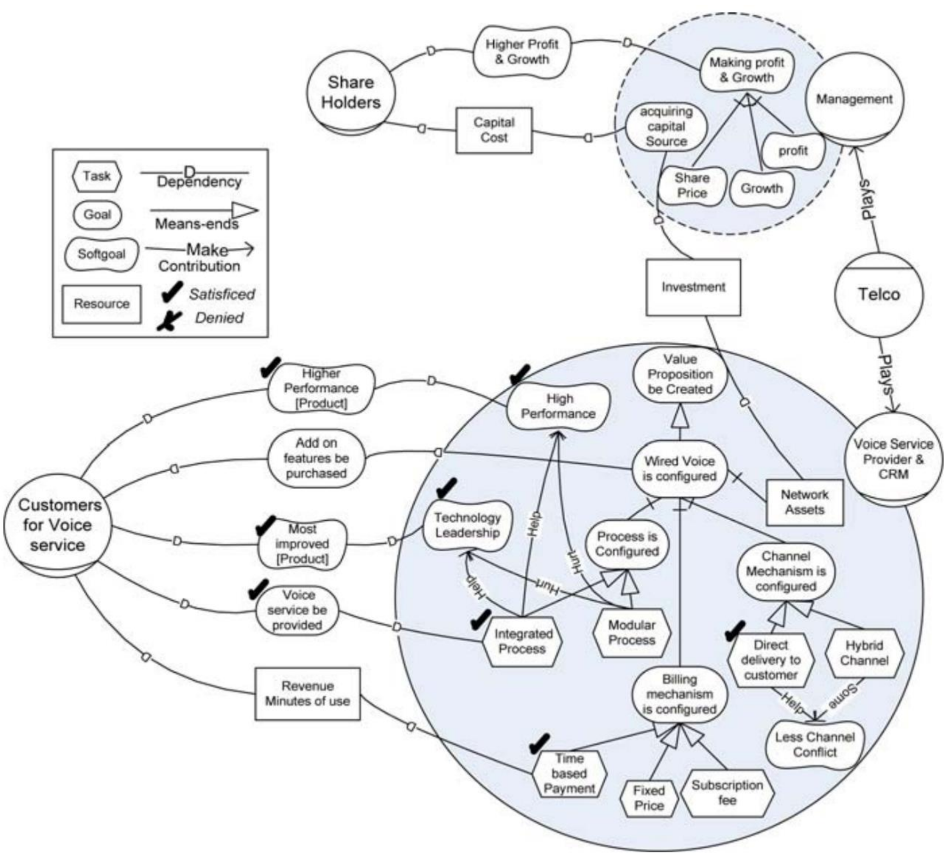

Figure A2. Strategic Business Model Ontology (Samavi et al., 2009)

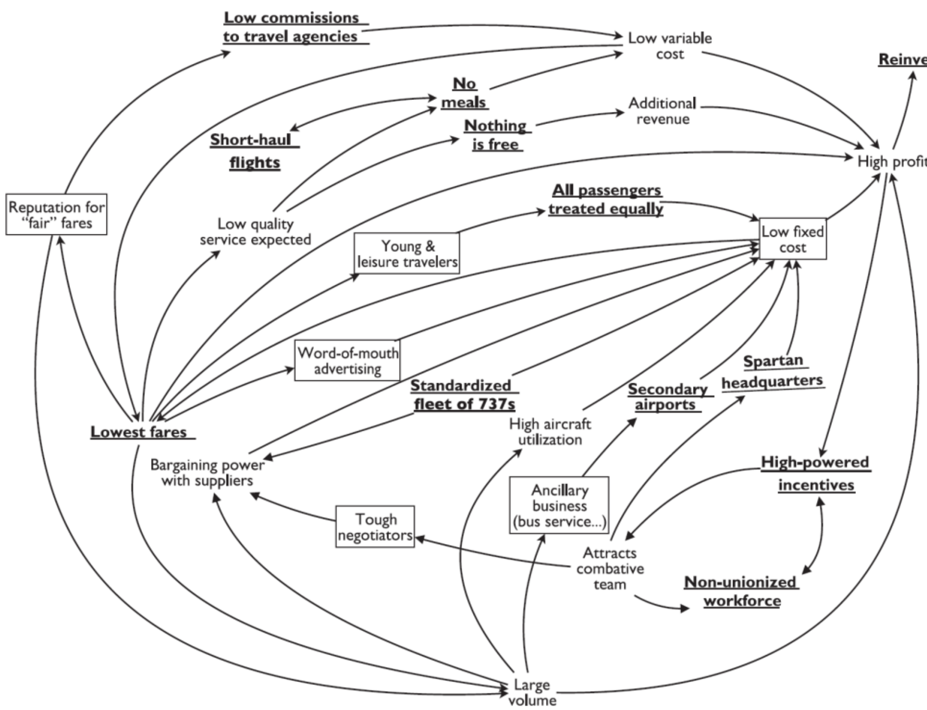

Figure A3. Causal Loop Diagram (Casadesus-Masanell & Ricart, 2010)

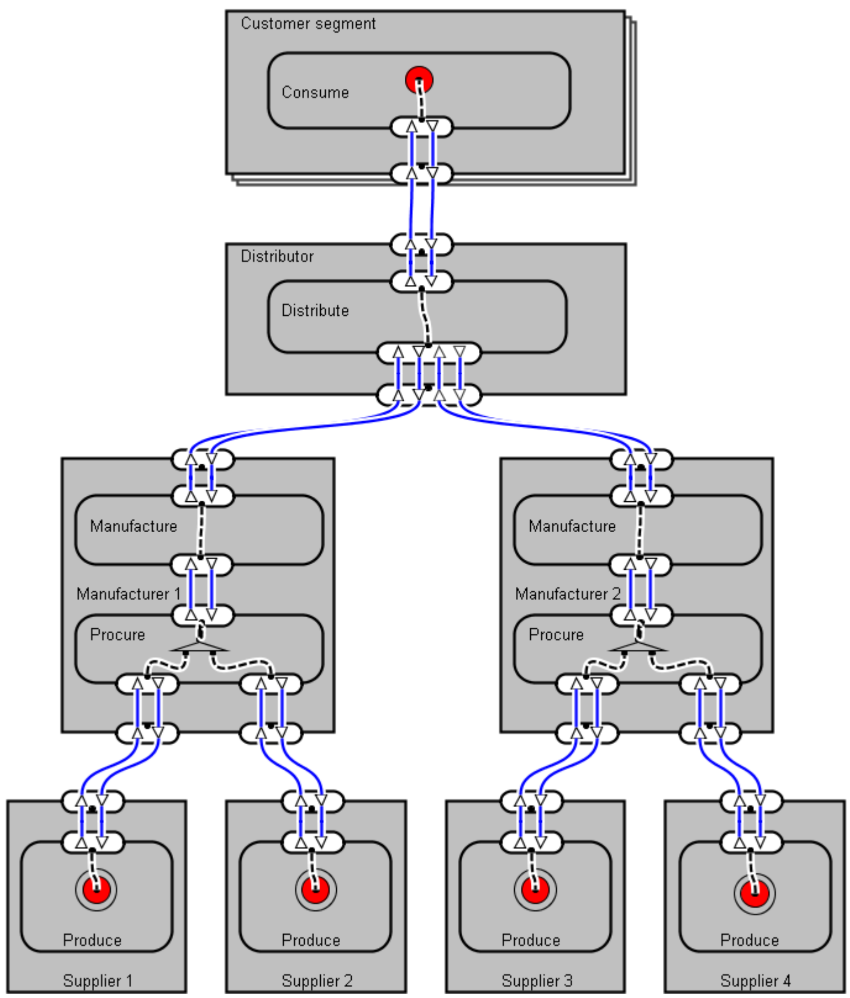

Figure A4. e3value (Gordijn & Akkermans, 2003)

Appendix B: Technical description of how we identified citations

Stage 1: Identifying citations using Google Scholar

To build the citation database, we identified the citations for each of the 17 BMMLs (i.e., citations of the publications that originally propose a BMML). Usually, citation analysis is carried out via academic databases using the “cited by” feature (e.g., Falagas, Pitsouni, Malietzis, & Pappas, 2008; Bakkalbasi, Bauer, Glover, & Wang, 2006; Meho & Yang, 2007). This feature allows to see which papers in an academic database cite a certain paper.

Recall that traditional academic databases such as EBSCO, Scopus, and Web of Science are limited in that such databases do not list academic books (and some of the BMMLs identified are published in academic books). To overcome this limitation and obtain a comprehensive picture of how BMMLs are employed in research, we used Google Scholar to identify papers that cite at least one of the BMMLs. Google Scholar indexes information from multiple sources (such as publishers, journals, and websites including academic databases), provides a “cited by” feature and lists all publications that were identified as a source of a BMML (and thereby allows to identify citations for all 17 BMMLs).

For each of the identified BMMLs, we exported from Google Scholar all citations up to July 2020, using the software “Harzing's Publish or Perish”. If a BMML is proposed by two papers (see Table B1), we exported the citations from both and collated them. The initial result set contains a total of 21,747 papers (see Table B1) which cite at least one of the 17 BMMLs. The export of citations from Google Scholar with “Harzing's Publish or Perish” involved two challenges:

- **Challenge 1:** Google Scholar partly provides truncated journal names only (e.g., “International Journal of ...” instead of the full name of the journal), and
- **Challenge 2:** Unlike academic databases, Google Scholar by default covers a wide range of publications in different BMMLs and contains a large number that is not useful for our purpose (e.g., theses, presentations, court opinions, patents, and other reports)

We respond to challenge 1 by manually checking and completing all citations with a truncated journal name. Furthermore, we respond to challenge 2 by focusing on journal papers written in English. The focus on journal papers increases the likelihood of identifying high-quality citations. Google Scholar does not allow to automatically filter for language and paper type. To remove all non-English and non-journal papers from the initial result set, we carried out a four-step filtering process (see Table B1).

- **Step 1:** We excluded citations that are either entirely empty or contain at least one of the following keywords in the field “source” (the field that contains the name of the journal if it is a journal paper): proceedings, conference or symposium, handbooks, thesis, or workshop.
- **Step 2:** We excluded citations that are marked by Google Scholar as books. Books in Google Scholar have a link (with “books.google” in that link) that leads to a preview in Google Books. We used that link to identify the book in our result set.
- **Step 3:** We excluded citations that are not published in English. For this, we 3a) manually excluded citations that have a title written in Cyrillic, Arabic, Chinese, Japanese or Korean characters, and we 3b) manually verified the remaining citations and excluded those that have a title written in Latin characters but not using English as a language (e.g., Spanish, Portuguese or German).
- **Step 4:** We automatically match the remaining citations with a list of journal names. For this, we 4a) created a list of all journals that are listed in the academic databases used for our study (EBSCO, Scopus, and Web of Science). This list comprises 48,654 different journal names. Afterward, we 4b) matched (using Microsoft Excels Fuzzy Lookup) the field “source” of the exported citations to the entries in the list of journal names. To qualify as a match, the journal name from the citation must have a similarity with one of the entries in the list of journal names that is greater than or equal to the similarity threshold. We configured the minimum similarity threshold to 0.95 (ranging from 0 for no similarity to 1 for an exact match). This allowed us to eliminate all Google Scholar citations whose publication name could not be matched with anyone of the journal names on the list. In so doing, and following prior research (e.g., Amankwah-Amoah, 2016; Seyedghorban, Matanda, & LaPlaca, 2016), we assumed that the inclusion of a journal in these databases ensures a sufficient journal quality.

We obtained a result set of 3,913 citations that cite at least one of the 17 BMMLs and that are published in a journal that is listed in one of the three academic databases we used for our study (EBSCO, Scopus, and Web of Science).

Table B1. The filtering process of identifying citations using Google Scholar

	Diagrammatic Business Model Representation (Boritz et al., 2014)	**Resource-Event-Agent** (Sonnenberg et al., 2011)	**e3value** (Gordijn & Akkermans, 2003)	**Eriksson-Penker Business Extensions** (Eriksson & Penker, 2000)	**Business Model Canvas** (Osterwalder & Pigneur, 2010)	**Business Models for eGovernment** (Peinel et al., 2010)	**Causal Map** (Cossette, 2002; Tsai et al., 2011)	**eBusiness Model Schematics** (Weill & Vitale, 2001)	**Strategic Business Model Ontology** (Samavi et al., 2009)	**Value Delivery Modeling Language** (OMG, 2015; Roelens & Poels, 2015)	**Value Stream Map** (Pynnönen et al., 2008)	**Service Dominant Business Model Radar** (Turetken et al., 2019)	**Activity System Business Model** (Gaspareto & Henriqson, 2020)	**Causal Loop Diagram** (Casadesus-Masanell & Ricart, 2010)	**Value Map** (Allee, 2000; Tapscott et al., 2000)	**Value Net** (Parolini, 1999)	**Framework for New Business Models** (Vorraber & Müller, 2019)	**Sum**
Stage 1																		
Number of citations in Google Scholar	9	33	1,085	1,827	11,518	18	17	1,592	105	13	222	20	1	2,501	2,304	666	2	21,933
Excluded in Step 1 (non-journal because conference etc.)	4	15	450	694	4,949	7	6	610	46	10	92	14	0	944	920	232	0	8,993
Excluded in Step 2 (non-journal because books)	0	0	44	84	504	1	0	82	4	0	12	0	0	87	171	48	0	1,037
Excluded in Step 3 (non-English)	0	0	98	260	2,960	1	8	335	9	0	6	0	0	502	335	100	0	4,614
Excluded in Step 4 (cannot be matched with one of the journal names of the academic databases)	0	12	324	549	1,350	4	2	263	20	1	47	4	0	315	377	107	1	3,376
Resulting number of English journal papers that can be matched with one of the journal names of the academic databases	5	6	169	240	1,755	5	1	302	26	2	65	2	1	653	501	179	1	3,913
Stage 2																		
Citations sampled for analysis by researchers (mainly reading abstract)	5	6	40	55	268	5	1	64	26	2	21	2	1	108	93	48	1	746
Citations read in depth by researchers (reading entire paper)	0	3	10	0	58	0	0	5	0	0	3	0	0	7	4	2	0	87[10]

Stage 2: Determine a sample of citations in journal papers

The large number of journal papers presented us with an additional challenge, which was to find a way to narrow down the sample of 3,913 to a manageable number while maintaining a good coverage of the received literature. This step was needed given that we did not intend to analyze citations using quantitative methods, but rather rely on an inductive approach based on a careful reading and critical assessment of each paper. A sample of 746 citations was selected for this citation analysis. We followed Jahangirian et al. (2011), who propose a review method for extremely large corpora of literature. The method suggests selecting a sample of the relevant literature based on three criteria, namely: citation count (so as not to miss the most frequently cited papers, which are likely to be highly relevant),

[10] In five of the 87 papers more than one Business Model Modeling Language is cited.

publication year (to counter the bias against more recent papers that the citation count criterion has), and random selection (to alleviate remaining biases). When implementing this method, we applied the outlined criteria separately for the citations of each BMML, so that the sample contains more citations of frequently cited BMMLs than of less frequently cited BMMLs. In this way, we arrived at a sample of 746 citations which we analyzed individually.

Some BMMLs have several hundred citations in journals, others one or two. We narrowed down and sampled the citations as follows:

9. We assigned each BMML a share of the sample proportional to the total number of citations across all BMMLs.
10. If a BMML has fewer than 30 citations, we decided to analyze all of them.
11. If a BMML has 30 or more citations, we followed Jahangirian et al. (2011) and combined the following sampling criteria: Citation count, year of publication, and random selection (Jahangirian et al., 2011). This means that for each year we sample 50 percent from the most highly cited papers and 50 percent randomly from the remaining set of papers.
12. Since (3) can only be applied for BMMLs with at least two citations in a year, for every year with just one citation, we sample that single paper.

Applying the approach described above leads us to a final result set of 746 papers (which is nearly 20 percent of all citations that cite at least one of the BMMLs and that are published in a journal). To start with, three of the authors coded a randomly selected sub-sample of 100 papers from our sample. For this, 10 papers were randomly selected from the sample which were coded by three authors individually and independently of each other. The coding was then discussed and resulted in a high degree of agreement among the authors as to which citations of BMML were relevant and which were not. In addition, the remaining 90 papers were randomly assigned to one of the three authors, i.e., each of them received 30 papers that cite at least one BMML. Reassuringly, we have found that only very few borderline cases required a brief coordination among the three authors. Given the three authors came to a joint verdict about the coding in these cases too, the remaining papers citing at least one BMML were coded by only one author. In doing so, the coder used the coding scheme below.

Not surprisingly, we found agreement about the recognition that many papers cite a BMML but without elaborating on it. For example, a substantial number of papers only mention the existence of BMMLs in their literature review, as a way of representing a business model (e.g., Vom Brocke et al., 2009; Carayannis, Sindakis, & Walter, 2015). These papers, however, by the mere fact of mentioning BMMLs, underline the relevance that these BMMLs have or are perceived to have. Nevertheless, as they do not elaborate on the BMML(s) beyond a single citation, they do not add to our understanding of these BMMLs.

To identify relevant citations, we required papers to talk about the BMMLs they cite in greater depth and more meaningfully, for example by extending BMMLs (e.g., Joyce & Paquin, 2016) or evaluating their advantages compared to competing approaches (e.g., Eppler & Hoffmann, 2012).

As part of the coding of the papers, we

13. read paper titles, journal names, and abstracts
14. determined which paper cites which BMML, and
15. screened which paper contains graphics representing BMMLs.

All papers have been coded and assigned to one of the following classifications by applying a two-dimensional coding scheme (see Table B2):

Table B2. Two-dimensional Coding Scheme

Classification \ Criterion	A paper's central subject of enquiry is a phenomenon other than a BMML itself, and at least one BMML is used to research that phenomenon.	A paper's central subject of enquiry is at least one BMMLs and knowledge about that BMML is advanced in terms of semantic, syntax, or pragmatics.
a) The paper presents research *with* a BMML	Yes	No
b) The paper presents research *about* a BMML	No	Yes
c) The paper merely cites a BMML	No	No

Where we were unsure about classifying a certain paper as part of the initial cursory analysis, we kept it in the result set for more detailed reading and re-evaluation. Conducting the three steps of the initial cursory analysis revealed that not all the identified papers would be useful for the purpose of our study which led us to reject 659 items that merely cite a BMML without any further elaboration. This led to a final sample of citations comprising 87 papers, all of which deal with BMMLs meaningfully, compared to the 659 papers which merely cite BMMLs. In a subsequent in-depth reading of the 87 papers, we analyzed how these papers employ BMMLs.

Stage 3: Validation

To validate our approach of identifying citations of papers that propose a BMML, we compare the citations we identified in stage (1) with those that can be identified using the more conventional approach of using the "cited by" feature of traditional academic databases. We chose the BMML-proposing paper with the most citations published in a journal (i.e., *Causal Loop Diagram* by Casadesus-Masanell & Ricart (2010), see Table B1) to analyze the number of citations that traditional academic databases list for that BMML. Comparing the two methods, our approach identifies 83 percent of the citations identified by EBSCO, 93 percent of the citations identified by Web of Science, and 82 percent of the citations identified by Scopus.

Appendix C: Scope and granularity of Business Model Modeling Languages

Table C1. Scope and granularity of Business Model Modeling Languages

#	BMML	Granularity	Scope
1	Diagrammatic Business Model Representation (Boritz et al., 2014)	5	2
2	Resource-Event-Agent (Sonnenberg et al., 2011)	4	4
3	e3value (Gordijn & Akkermans, 2003)	7	8
4	Eriksson-Penker Business Extensions (Eriksson & Penker, 2000)	5	2
5	Business Model Canvas (Osterwalder & Pigneur, 2010)	9	11
6	Business Models for eGovernment (Peinel et al., 2010)	7	5
7	Causal Map (Cossette, 2002; Tsai et al., 2011)	2	16
8	eBusiness Model Schematics (Weill & Vitale, 2001)	8	5
9	Strategic Business Model Ontology (Samavi et al., 2009)	5	4
10	Value Delivery Modeling Language (OMG, 2015; Roelens & Poels, 2015)	19	10
11	Value Stream Map (Pynnönen et al., 2008)	7	7
12	Service Dominant Business Model Radar (Turetken et al., 2019)	5	7
13	Activity System Business Model (Gaspareto & Henriqson, 2020)	6	6
14	Causal Loop Diagram (Casadesus-Masanell & Ricart, 2010)	3	16
15	Value Map (Allee, 2000; Tapscott et al., 2000)	6	4
16	Value Net (Parolini, 1999)	8	5
17	Framework for New Business Models (Vorraber & Müller, 2019)	23	8

Appendix D: Author's intention to use a Business Model Modeling Language

Table D1. Author's intention to use a Business Model Modeling Language

Business Model Modeling Language	Statement saying that the perspective offered is intended to model "every" or "several" business models
Diagrammatic Business Model Representation (Boritz et al., 2014)	"This study investigates one aspect of the business model representation issue by exploring the relative merits of two key types of representations of business models for risk assessment purposes—a diagram and a tabular representation. […] The diagram representation was designed to implement the features discussed earlier in the review of the literature on external knowledge representations." (Boritz et al., 2014, p. 232)
Resource-Event-Agent (Sonnenberg et al., 2011)	"Business models specify—amongst other things—the main actors, their relationships and the values exchanged between them [...] We see three main ontologies to conceptualize business models: the Business Model Ontology, the e3-value ontology, and the Resource-Event-Agent ontology (REA). […] In this paper we proposed a domain specific modeling language to support the conceptual modeling of economic events based on the REA ontology. […] In our case, the relationships between the core concepts are precisely defined by using OMG's Meta Object Facility (MOF) leading to a dedicated REA domain specific modeling language. The MOF-based approach enables the development of a graphical syntax that is dedicated to the needs of business modeling." (Sonnenberg et al., 2011, p. 252 + 265)
e3value (Gordijn & Akkermans, 2003)	"We propose an interdisciplinary approach, e3value, to explore an innovative e-commerce idea with the aim of understating such an idea thoroughly and evaluating it for potential profitability. Our methodology exploits a requirements engineering way of working, but employs concepts and terminology from business science, marketing and axiology. It shows how to model business requirements and improve business-IT alignment, in sophisticated multi-actor value constellations that are common in electronic commerce." (Gordijn & Akkermans, 2003, p. 114)
Eriksson-Penker Business Extensions (Eriksson & Penker, 2000)	"However, when modeling the surroundings of the information system, you are no longer modeling software. Enter the world of business modeling. There can be many reasons for doing business modelling: To better understand the key mechanisms of an existing business. […] To act as the basis for creating suitable information systems that support the business. […] To act as the basis for improving the current business structure and operation. […] To show the structure of an innovated business. The model becomes the basis for the action plan. […] This article (and the book from which it is an extract) discusses how UML also can be used for business modelling and thus demonstrate that the same modeling language can be used for the business models as for the software models." (Eriksson & Penker, 2000, p. 2 of summary)
Business Model Canvas (Osterwalder & Pigneur, 2010)	"A shared language for describing, visualizing, assessing, and changing business models" (Osterwalder & Pigneur, 2010, p. 12)
Business Models for eGovernment (Peinel et al., 2010)	"This paper describes a new modeling method named BMeG (Business Models for eGovernment) supporting the planning of business models for eGovernment services." (Peinel et al., 2010, p. 380)
Causal Map (Cossette, 2002; Tsai, Lin, & Su, 2011)	"This study proposes a new systematic method to explore business model structure." (Tsai et al., 2011, p. 235)

Table D1 (cont.). Author's intention to use a Business Model Modeling Language

Business Model Modeling Language	Statement saying that the perspective offered is intended to model "every" or "several" business models
eBusiness Model Schematics (Weill & Vitale, 2001)	"In chapter 2 we define a business model and provide a practical framework for understanding both physical and electronic ways of doing business. Chapter 2 also introduces a simple but powerful tool to represent and analyze e-business models: the e-business model schematic. The use of e-business model schematics allows an organization to analyze its current business model and develop and analyze e-business initiatives." (Weill & Vitale, 2001, p. 26)
Strategic Business Model Ontology (Samavi et al., 2009)	"In this paper we define a strategic modeling framework to help understand and analyze the goals, intentions, roles, and the rationale behind the strategic actions in a business environment. […] The key component of the framework is a strategic business model ontology for representing and analyzing business models and strategies, using the i* agent and goal oriented methodology as a basis." (Samavi et al., 2009, p. 171)
Value Delivery Modeling Language (OMG, 2015; Roelens & Poels, 2015)	"A proper business model representation helps to increase the understanding and communication about the underlying knowledge for the stakeholders within a company. However, the existing enterprise modeling languages have a different and partial focus on the business model concept due to their various backgrounds. This prevents the large-scale adoption of these representations in practice. Therefore, a focused business model viewpoint is developed. […] This paper finishes the development of a focused business model representation. Previous research already identified the components of a business model and investigated whether relevant enterprise modeling languages capture these components. This resulted in a set of VDML meta-model constructs that cover the complete business model. This paper develops and evaluates a new business model viewpoint that facilitates the understanding of the underlying business model knowledge." (Roelens & Poels, 2015, p. 61)
Value Stream Map (Pynnönen, Hallikas, & Savolainen, 2008)	"As stated in the introduction above, the objective of our research is to develop the SDBM/R—a visual template to represent service-dominant business models, which depicts the way that a network of organizations co-creates a value for a specific customer group through a solution-oriented service and generates revenue and benefits for all network parties." (Turetken et al., 2019, p. 14)
Service Dominant Business Model Radar (Turetken, Grefen, Gilsing, & Adali, 2019)	"As stated in the introduction above, the objective of our research is to develop the SDBM/R—a visual template to represent service-dominant business models, which depicts the way that a network of organizations co-creates a value for a specific customer group through a solution-oriented service and generates revenue and benefits for all network parties." (Turetken et al., 2019, p. 14)
Activity System Business Model (Gaspareto & Henriqson, 2020)	"[for] delivering a visual representation of business models based on activity systems" (Gaspareto & Henriqson, 2020, p. 7)
Causal Loop Diagram (Casadesus-Masanell & Ricart, 2010)	"to introduce a tool to represent business models" (Casadesus-Masanell & Ricart, 2010, p. 198)

Table D1 (cont.). Author's intention to use a Business Model Modeling Language

Business Model Modeling Language	Statement saying that the perspective offered is intended to model "every" or "several" business models
Value Map (Allee, 2000; Tapscott et al., 2000)	"The key to reconfiguring business models for the knowledge economy lies in understanding the new currencies of value. […] Using the same example we can 'map' these value exchanges as a flow diagram showing goods, services, and revenue (GSR), knowledge flow, and creation of intangible value. […] More examples of value network analysis applied to e-business webs are featured in the recent book, Digital Capital, by Don Tapscott, David Ticoll, and Alex Lowy (Harvard Business School Press, 2000)" (Allee, 2000, p. 39) "A value map is a graphical depiction of how a b-web operates, or will operate in the future […] We identify all the key classes of participants, including strategic partners, suppliers, and customers. In mapping, we view b-webs as complex systems in which the players exchange three qualitatively different, yet equally vital kinds of value: 1. Tangible benefits: […] 2. Knowledge: […] 3. Intangible benefits: […] To visualize the new value-creating system, construct a value map. Include all key classes of participants and the most important value." (Tapscott 2008, p. 224) Extra note from Zott et al. (2011): "Tapscott et al. (2000) suggest a value map for depicting how a business web operations. The value map depicts all key classes of participants (partners, customers, suppliers) and value exchanges between them (tangible benefits and knowledge)" (Zott et al., 2011, p. 1026)
Value Net (Parolini, 1999)	"The new business model seems to be characterized by an emphasis on well-defined distinctive skills, the ability to exploit these in different markets" (Parolini, 1999, p. xxi) Extra note from Massa and Tucci (2014): "In addition, they noted that the phenomenon of value creation as depicted by the business model typically accours in a value network (cf. Normann & Ramirez, 1993; Parolini 1999)" (Massa & Tucci, 2014, p. 423)
Service Analysis and Engineering Framework for New Business Models (Vorraber & Müller, 2019)	"This paper proposes a multi-layer framework to analyze existing business models as well as to shape new business ventures in a networked and values-based way and to support the identification of tacit network effects within business ecosystems. Based on an existing multi-layered analysis toolkit, focusing on legal and business dynamics aspects, an enhanced visualization and analysis tool is proposed that focuses especially on ethical, social and environmental aspects to foster the creation of (strongly) sustainable business models." (Vorraber & Müller, 2019, p. 1)

Appendix E: Semantics - The meaning of Business Model Modeling Languages

Table E1 provides an overview of the semantic constructs that are available in the various BMMLs. The table reads as follows: The left-most column contains the dimensions and sub-dimensions of the business model definition by Al-Debei and Avison (2010) that serves as a reference for the analysis. The remaining columns comprise the semantic constructs of the identified 17 BMMLs. Filled cells have the name of the semantic constructs in the terminology of the respective BMMLs. Empty cells stand for (sub-)dimensions that a certain BMML does not cover with semantic constructs. Different names in cells of the same row reveal the use of different terminology for semantic constructs within the same (sub-)dimension across BMMLs. Cells that span multiple rows reveal semantic constructs of BMMLs that incorporate more than one (sub-)dimensions. Names of semantic constructs listed more than once in a column (i.e., BMML) cover two or more (sub-)dimensions.

Table E1. Semantics: The meaning in Business Model Modeling Languages

<table>
<tr><th colspan="2">Semantic dimensions and sub-dimensions of the business model concept (Al-Debei and Avison, 2010;Al-Debei and Fitzgerald, 2010)</th><th>Diagrammatic Business Model Representation (Boritz et al., 2014)</th><th>Resource-Event-Agent (Sonnenberg et al., 2011)</th><th>e3value (Gordijn & Akkermans, 2003)</th><th>Eriksson-Penker Business Extensions (Eriksson & Penker, 2000)</th><th>Business Model Canvas (Osterwalder & Pigneur, 2010)</th><th>Business Models for eGovernment (Peinel et al., 2010)</th><th>Causal Map (Cossette, 2002; Tsai et al., 2011)</th><th>eBusiness Model Schematics (Weill & Vitale, 2001)</th><th>Strategic Business Model Ontology (Samavi et al., 2009)</th><th>Value Delivery Modeling Language (OMG, 2015; Roelens & Poels, 2015)</th><th>Value Stream Map (Pynnönen et al., 2008)</th><th>Service Dominant Business Model Radar (Turetken et al., 2019)</th><th>Activity System Business Model (Gaspareto & Henriqson, 2020)</th><th>Causal Loop Diagram (Casadesus-Masanell & Ricart, 2010)</th><th>Value Map (Allee, 2000; Tapscott et al., 2000)</th><th>Value Net (Parolini, 1999)</th><th>Framework for New Business Models (Vorraber & Müller, 2019)</th></tr>
<tr><td rowspan="3">Value-proposition</td><td>Intended-value-element</td><td></td><td></td><td rowspan="2">Value object</td><td></td><td rowspan="2">Value proposition</td><td></td><td rowspan="10">Concepts, links</td><td></td><td></td><td>Value Proposition, Component</td><td></td><td>Actor value proposition, Co-created value-in-use</td><td>Value proposition</td><td rowspan="10">Choices (Policy, asset, and governance), conse-quences (flexible/ rigid), links</td><td></td><td></td><td>Brand, product, information, service, coordination, monetary value, intangible value</td></tr>
<tr><td>Product-service</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Business Item</td><td>Service, free service, product, free product,</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Target-segment</td><td></td><td>Outside agent</td><td rowspan="3">Actor, market segment</td><td></td><td>Customer segments</td><td></td><td>Customer</td><td rowspan="2">Agent</td><td rowspan="2">Participant, Organi-zational Unit, Community</td><td rowspan="2">Actor</td><td rowspan="2">Actor</td><td>Customer segment</td><td rowspan="2">Member</td><td rowspan="2">Actor</td><td rowspan="2">Actor/Name</td></tr>
<tr><td rowspan="7">Value-network</td><td>Actor</td><td></td><td>Inside agent, outside agent</td><td></td><td rowspan="2">Customer segments, key partners</td><td>Partner</td><td rowspan="2">Customer, firm of interest, supplier, ally</td><td></td></tr>
<tr><td>Role</td><td></td><td></td><td></td><td>Role</td><td>Role</td><td>Role, Party</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Flow-communi-cation*</td><td></td><td></td><td>Value object</td><td></td><td></td><td rowspan="2">Object exchange</td><td>Money, product, information</td><td></td><td>Business Item, Deliverable Flow</td><td rowspan="2">Service, free service, product, free product, information</td><td></td><td></td><td rowspan="2">Good, service, revenue, knowledge, intangible benefits</td><td rowspan="2">Financial, good, information, influence</td><td rowspan="2">Provision link, revenue link, value engine, value break</td></tr>
<tr><td>Relation-ship</td><td>Intra- or inter-category linkages</td><td>Economic resource flow</td><td>Value exchange/ port/ interface</td><td></td><td>Customer relationship</td><td>Electronic relationship, primary relationship</td><td></td><td>Business Network, Port Container, Input Port, Output Port, Value Add</td><td></td><td></td></tr>
<tr><td>Channel</td><td></td><td></td><td></td><td></td><td>Channels</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gover-nance</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Legal obligations</td></tr>
<tr><td>Network-mode</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table E1 (cont.). Semantics: The meaning in Business Model Modeling Languages

Semantic dimensions and sub-dimensions of the business model concept (Al-Debei and Avison, 2010; Al-Debei and Fitzgerald, 2010)		**Diagrammatic Business Model Representation** (Boritz et al., 2014)	**Resource-Event-Agent** (Sonnenberg et al., 2011)	**e3value** (Gordijn & Akkermans, 2003)	**Eriksson-Penker Business Extensions** (Eriksson & Penker, 2000)	**Business Model Canvas** (Osterwalder & Pigneur, 2010)	**Business Models for eGovernment** (Peinel et al., 2010)	**Causal Map** (Cossette, 2002; Tsai et al., 2011)	**eBusiness Model Schematics** (Weill & Vitale, 2001)	**Strategic Business Model Ontology** (Samavi et al., 2009)	**Value Delivery Modeling Language** (OMG, 2015; Roelens & Poels, 2015)	**Value Stream Map** (Pynnönen et al., 2008)	**Service Dominant Business Model Radar** (Turetken et al., 2019)	**Activity System Business Model** (Gaspareto & Henriqson, 2020)	**Causal Loop Diagram** (Casadesus-Masanell & Ricart, 2010)	**Value Map** (Allee, 2000; Tapscott et al., 2000)	**Value Net** (Parolini, 1999)	**Framework for New Business Models** (Vorraber & Müller, 2019)
Value-architecture	Core-compe-tency							Concepts, links			Capability Offer			Activity system	Choices (Policy, asset, and governance), conse-quences (flexible/ rigid), links			Capabilities
	Core-resource				Resource	Key resources					Store	Resource						Assets
	Value-configu-ration	Internal processes & resources	Business process	Activity	Core process	Key activities	Service			Task	Capability Method, High-level Activity	Service, free service	Co-production activity				Mgmt. of external transactions, support, realization	
Value-finance	Total-cost-of-ownership					Cost structure							Cost/benefit	Profit logic				
	Pricing-method					Revenue streams												
	Revenue-structure																	
Additional		Environment /external factors, relevant strategic goals, impact on accounts, Intra- or inter-category linkages			Domain-specific concepts, quantitative goal, qualitative goal		Advantage, disadvantage, Policy			Goal, soft goal				Business definition, Critical factors of value proposition				Functional needs, technical nonfunctional needs, social economic needs, social human needs, ethical needs, safety needs Endogenous motivation, exogenous influence

Appendix F: Research *with* a Business Model Modeling Language

Table F1. Research *with* a Business Model Modeling Language (BMML)

Citation	Strategy											Inf. Syst.	
	Waldner et al., 2013	Rask, 2014	Savall & Hillon, 2017	Pinto et al., 2017	Grimes, 2018	Pynnönen & Kytölä, 2008	Pynnönen et al., 2011	Pynnönen, Hallikas, & Ritala, 2012	Reim et al., 2015	Partanen & Möller, 2012	Mikkonen et al., 2008	Sedbrook, 2012	Lin et al., 2010
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)												X	
e3value (Gordijn and Akkermans, 2003)													X
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X								
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)						X	X	X					
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)									X				
Value Map (Allee, 2000; Tapscott et al., 2000)						X							
Value Net (Parolini, 1999)										X	X		
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations	X			X			X						X
To understand network-based business models						X		X		X	X		
To study business model innovation — both design and reconfiguration		X	X		X				X				
To align business and IT in organizations													
To incorporate business models into software development methods												X	
To support business model implementation													X
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts		X						X	X	X		X	
By using BMMLs for data collection				X	X								
By using BMMLs for business model analysis	X			X			X						
By using BMMLs for result communication													X

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Information Systems (cont.)												
	de Castro et al., 2011	Gordijn, 2005	Tongrungrojana & Lowe, 2004	Bleistein et al., 2006	Razo-Zapata et al., 2015	Riasanow et al., 2018	Kok et al., 2008	Han et al., 2016	Cai et al., 2008	Weigand et al., 2007	Mettler & Eurich, 2012	Kartseva et al., 2004	Flötgen et al., 2020
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)	X	X	X	X	X	X	X	X	X	X	X	X	X
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)													
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)													
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations								X	X	X			
To understand network-based business models		X			X		X					X	X
To study business model innovation — both design and reconfiguration						X		X	X	X	X		
To align business and IT in organizations			X	X									
To incorporate business models into software development methods	X												
To support business model implementation													
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts	X		X	X									
By using BMMLs for data collection								X					
By using BMMLs for business model analysis	X					X	X	X	X	X		X	
By using BMMLs for result communication	X	X			X	X	X		X	X	X	X	X

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Information Systems (cont.)												
	Riasanow et al., 2018	Pratama & Iijima, 2019	Peters et al., 2015	Sakellaridis & Stiakakis, 2011	John, 2016	Augenstein & Mädche, 2017	Schaffer et al., 2020	Augenstein & Fleig, 2017	Potocnjak-Oxman, 2018	Schirmer et al., 2020	Lawson et al., 2015	Bonazzi & Pigneur, 2015	Szopinski et al., 2020
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)	X	X											
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)		X	X	X	X	X	X	X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)													
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations		X		X		X		X					X
To understand network-based business models	X												
To study business model innovation — both design and reconfiguration		X	X		X	X	X	X		X	X	X	X
To align business and IT in organizations													
To incorporate business models into software development methods													
To support business model implementation									X				
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts		X	X	X	X	X	X	X					
By using BMMLs for data collection				X									X
By using BMMLs for business model analysis									X				
By using BMMLs for result communication	X									X	X	X	

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Information Systems (cont.)												
	Augenstein et al., 2018	Schultze, 2002	Rensmann, 2012	Görzen & Kundisch, 2016	Szopinski et al., 2017	Zolnowski & Böhmann, 2011	Stuckenberg et al., 2011	Zolnowski et al., 2011	Görzen, 2019	Toutaoui & Benlian 2020	Lee & Kang, 2019	Schmidt et al., 2018	Rothe & Steier, 2017
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)													
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X	X	X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)													
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations	X	X	X		X		X			X		X	
To understand network-based business models													X
To study business model innovation — both design and reconfiguration		X	X	X	X	X		X	X	X		X	X
To align business and IT in organizations													
To incorporate business models into software development methods													
To support business model implementation													
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts	X					X					X		
By using BMMLs for data collection	X	X	X	X	X		X		X	X		X	X
By using BMMLs for business model analysis		X	X							X			
By using BMMLs for result communication								X		X		X	

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Information Systems (cont.)											Sustainability	
	Schultze & Orlikowski, 2004	Standing et al., 2008	Tura et al., 2017	Musulin & Strahonja, 2018	Schultze, 2003	Schultze, 2002	Joyce, 2012	Gilsing et al., 2018	Gilsing et al., 2020	Costa & Da Cunha, 2009	Alves & Roque, 2005	Sinkovics, Sinkovics, & Yamin,	Gorissen et al., 2016
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)													
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)												X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)	X	X	X	X	X	X	X						
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)								X	X				
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)										X			
Value Net (Parolini, 1999)											X		
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations	X				X	X	X			X		X	
To understand network-based business models	X							X	X	X			
To study business model innovation — both design and reconfiguration		X	X						X		X		X
To align business and IT in organizations				X									
To incorporate business models into software development methods													
To support business model implementation			X										
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts			X				X			X			X
By using BMMLs for data collection			X									X	
By using BMMLs for business model analysis	X				X	X					X	X	
By using BMMLs for result communication		X	X	X	X			X	X		X		

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

	Sustainability (cont.)						Business Model						
Citation	Behet al., 2016	França et al., 2017	Todeschini et al., 2017	Heyes et al., 2018	Lopez et al., 2019	Le et al., 2019	Derks et al., 2018	D' Souza et al., 2015	Djelassi & Decoopman 2013	Shinde et al., 2013	Alemán & Lugo-Ocando	Jackson et al., 2015	Segarra et al., 2016
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)							X	X					
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X		X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)													
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations								X			X		
To understand network-based business models							X	X	X				
To study business model innovation — both design and reconfiguration	X	X	X	X	X	X	X						
To align business and IT in organizations													
To incorporate business models into software development methods													
To support business model implementation										X			X
To support pedagogical goals in entrepreneurship												X	
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts										X		X	X
By using BMMLs for data collection	X			X		X							X
By using BMMLs for business model analysis	X		X	X				X			X		X
By using BMMLs for result communication		X		X	X	X	X	X	X	X			

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Business Model (cont.)												
	Sundin et al., 2016	Petri, 2014	Gabriel & Kirkwood, 2016	Lam & Yu, 2016	Cherif & Grant, 2014	Yablonsky, 2016	Sepponen & Heimonen, 2016	Witell & Löfgren, 2013	Nielsen & Roslender, 2015	Metallo et al., 2018	Hacklin et al., 2018	Pfeifer et al., 2018	Grustam et al., 2018
WHICH (BMMLs are used)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)													
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X	X	X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)													
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLs used for)?													
To describe the business model of existing organizations	X		X	X	X			X	X	X		X	
To understand network-based business models						X							
To study business model innovation — both design and reconfiguration		X					X			X	X	X	X
To align business and IT in organizations													
To incorporate business models into software development methods													
To support business model implementation													
To support pedagogical goals in entrepreneurship													
HOW (are BMMLs used)?													
By using BMMLs for developing new artifacts						X	X		X				
By using BMMLs for data collection	X				X					X	X	X	
By using BMMLs for business model analysis	X	X	X		X			X		X	X	X	
By using BMMLs for result communication				X						X			X

Table F1 (cont.). Research *with* a Business Model Modeling Language (BMML)

Citation	Business Model (cont.)											
	Morkunas et al., 2019	Müller, 2019	Huhtala et al., 2019	Polydoropoulou et al., 2020	Rydehell, 2020	Laszczuk & Mayer, 2020	Papachristos, 2019	Aversa et al.,2021	Snihur & Tarzijan, 2018	Pereira & Caetano, 2015	Kiani 2009	Montemari & Nielsen, 2013
WHICH (BMMLs are used)?												
Diagrammatic Business Model Representation (Boritz et al., 2014)												
Resource-Event-Agent (Sonnenberg et al., 2011)												
e3value (Gordijn and Akkermans, 2003)												
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)												
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X						
Business Models for eGovernment (Peinel et al., 2010)												
Causal Map (Cossette, 2002; Tsai et al., 2011)												
eBusiness Model Schematics (Weill and Vitale, 2001)												
Strategic Business Model Ontology (Samavi et al., 2009)												
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)												
Value Stream Map (Pynnönen et al., 2008)												
Service Dominant Business Model Radar (Turetken et al., 2019)												
Activity System Business Model (Gaspareto and Henriqson, 2020)												
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)							X	X	X	X	X	X
Value Map (Allee, 2000; Tapscott et al., 2000)												
Value Net (Parolini, 1999)												
Framework for New Business Models (Vorraber and Müller, 2019)												
WHAT (are BMMLs used for)?												
To describe the business model of existing organizations		X				X	X			X		
To understand network-based business models					X							X
To study business model innovation — both design and reconfiguration	X		X	X	X	X		X	X		X	
To align business and IT in organizations												
To incorporate business models into software development methods												
To support business model implementation	X											
To support pedagogical goals in entrepreneurship												
HOW (are BMMLs used)?												
By using BMMLs for developing new artifacts										X		
By using BMMLs for data collection		X			X	X						
By using BMMLs for business model analysis		X	X		X	X	X		X		X	X
By using BMMLs for result communication	X			X				X				

Appendix G: Research *about* a Business Model Modeling Language

Table G1. Research *about* a Business Model Modeling Language (BMML)

Citation	Strat.	Information Systems											
	Allee, 2008	Johnson et al., 2014	Gordijn et al., 2006	Baida et al., 2003	Kundisch & John, 2012	Derzsi et al., 2008	Terrenghi et al., 2018	Schwarz & Legner, 2020	Becker et al., 2011	Iacob et al., 2012	John & Kundisch, 2015	Athanasopoulou & de Reuver,	Avdiji et al., 2018
WHICH (BMMLs are being researched)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)		X	X	X	X	X	X	X	X				
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)								X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)									X				
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)									X				
Value Map (Allee, 2000; Tapscott et al., 2000)	X												
Value Net (Parolini, 1999)													
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLS researched for)?													
To support the application of a BMML	X				X		X	X			X		
To support the development of software		X	X	X		X				X			
To design business model development software		X		X									
To design business models for sustainability													
To investigate specific contexts such as risk analysis, platforms or crowdsourcing					X	X	X						
To support pedagogical goals in entrepreneurship													
To support business model idea generation												X	
To support the theoretical foundation								X	X		X		X
HOW (is the WHAT realized)?													
By linking BMMLs with other modeling languages		X	X	X		X				X			
By extending a BMML's semantics					X		X						
By extending a BMML's syntax					X		X						
By extending a BMML's pragmatics	X										X		
By evaluating a BMML											X	X	
By formulating design knowledge								X	X				X

Table G1 (cont.). Research *about* a Business Model Modeling Language (BMML)

Citation	Information Systems (cont.)									Sustainability			
	Avdiji et al., 2020	Zolnowski et al., 2014	Zolnowski & Böhmann, 2014	Plenter et al., 2017	Rose et al., 2019	Fritscher & Pigneur, 2014	Kühne & Böhmann, 2018	Kühne & Böhmann, 2019	Biem & Caswell, 2008	Lewandowski, 2016	Joyce & Paquin, 2016	Cosenz et al., 2020	Baldassarre et al., 2020
WHICH (BMMLs are being researched)?													
Diagrammatic Business Model Representation (Boritz et al., 2014)													
Resource-Event-Agent (Sonnenberg et al., 2011)													
e3value (Gordijn and Akkermans, 2003)									X				
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)													
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X	X	X		X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)													
Causal Map (Cossette, 2002; Tsai et al., 2011)													
eBusiness Model Schematics (Weill and Vitale, 2001)													
Strategic Business Model Ontology (Samavi et al., 2009)													
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)													
Value Stream Map (Pynnönen et al., 2008)													
Service Dominant Business Model Radar (Turetken et al., 2019)													
Activity System Business Model (Gaspareto and Henriqson, 2020)													
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)													
Value Map (Allee, 2000; Tapscott et al., 2000)									X			X	
Value Net (Parolini, 1999)									X				
Framework for New Business Models (Vorraber and Müller, 2019)													
WHAT (are BMMLS researched for)?													
To support the application of a BMML		X	X			X							
To support the development of software													
To design business model development software						X							
To design business models for sustainability										X	X	X	X
To investigate specific contexts such as risk analysis, platforms or crowdsourcing		X	X	X	X		X	X	X				
To support pedagogical goals in entrepreneurship													
To support business model idea generation		X											
To support the theoretical foundation	X												
HOW (is the WHAT realized)?													
By linking BMMLs with other modeling languages									X				
By extending a BMML's semantics		X		X	X		X	X	X	X	X	X	X
By extending a BMML's syntax		X		X	X		X	X	X	X	X	X	X
By extending a BMML's pragmatics			X			X							
By evaluating a BMML		X	X	X	X	X							
By formulating design knowledge													

Table G1 (cont.). Research *about* a Business Model Modeling Language (BMML)

Citation	Sustainability (cont.)				Business Model					
	Mazzarol et al., 2018	Bocken et al., 2018	Andreassen et al., 2018	Kurucz et al., 2017	Sousa et al., 2012	Kohler, 2015	Leschke, 2013	Eppler & Hoffmann, 2012	Haaker et al., 2017	Henike et al., 2020
WHICH (BMMLs are being researched)?										
Diagrammatic Business Model Representation (Boritz et al., 2014)										
Resource-Event-Agent (Sonnenberg et al., 2011)										
e3value (Gordijn and Akkermans, 2003)										
Eriksson-Penker Business Extensions (Eriksson and Penker, 2000)										
Business Model Canvas (Osterwalder and Pigneur, 2010)	X	X	X	X	X	X	X	X	X	X
Business Models for eGovernment (Peinel et al., 2010)										
Causal Map (Cossette, 2002; Tsai et al., 2011)										
eBusiness Model Schematics (Weill and Vitale, 2001)										
Strategic Business Model Ontology (Samavi et al., 2009)										
Value Delivery Modeling Language (OMG, 2015; Roelens and Poels, 2015)										
Value Stream Map (Pynnönen et al., 2008)										
Service Dominant Business Model Radar (Turetken et al., 2019)										
Activity System Business Model (Gaspareto and Henriqson, 2020)										
Causal Loop Diagram (Casadesus-Masanell and Ricart, 2010)										
Value Map (Allee, 2000; Tapscott et al., 2000)										X
Value Net (Parolini, 1999)										
Framework for New Business Models (Vorraber and Müller, 2019)										
WHAT (are BMMLS researched for)?										
To support the application of a BMML										
To support the development of software										
To design business model development software										
To design business models for sustainability	X	X	X	X						
To investigate specific contexts such as risk analysis, platforms or crowdsourcing			X		X	X			X	
To support pedagogical goals in entrepreneurship							X			
To support business model idea generation								X		
To support the theoretical foundation										X
HOW (is the WHAT realized)?										
By linking BMMLs with other modeling languages										
By extending a BMML's semantics	X	X	X	X	X	X	X		X	
By extending a BMML's syntax	X	X	X	X			X		X	
By extending a BMML's pragmatics								X		
By evaluating a BMML								X		X
By formulating design knowledge										

About the Authors

Daniel Szopinski holds a doctorate degree in information systems and was a research associate at the chair of Business Information Systems, esp. Digital Markets at Paderborn University. His research focuses on business model innovation, modeling languages for business models and software tools for business model development. From a methodological point of view, he focuses on controlled experiments and participatory observations.

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